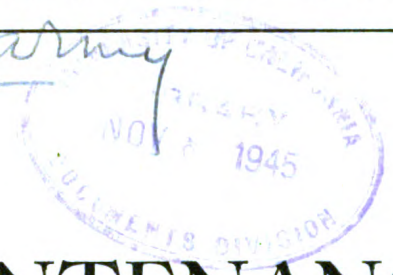
TM 5-630

WAR DEPARTMENT TECHNICAL MANUAL



GROUNDS MAINTENANCE, DUST and EROSION CONTROL

REPAIRS AND UTILITIES

WAR DEPARTMENT • SEPTEMBER 1945

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G. C. MARSHALL
Chief of Staff

OFFICIAL:
EDWARD F. WITSELL
Major General
Acting The Adjutant General

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Refer to FM 21–6 for explanation of distribution formula.

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Section 1
INTRODUCTION

1. Purpose and Scope

This Technical Manual discusses the factors contributing to efficient maintenance of grounds occupied by posts, camps, and stations. It gives information and outlines procedures for post engineers and personnel engaged in grounds-maintenance work. It aims to provide the post's using services a satisfactory environment with a minimum expenditure of money, personnel, and material. The scope of the manual includes growth of vegetation; maintenance of lawns, recreational areas, and airfields; dust and erosion control; soil conservation and improvement; stabilization of grades, banks, and ditches; and post cemeteries.

2. Responsibility and Organization of Personnel

The post engineer is responsible for maintenance of grounds, including revegetation, renovation, fertilization and mowing of grass, dust and erosion control, and use and care of all maintenance equipment incidental to this work. Prompt acceptance of this responsibility and early recognition of its problems are essential to success.

a. Maximum results with minimum cost require an efficient organization headed by a dependable supervisor who has, preferably, an agricultural background and knows grounds-maintenance equipment. He should also be familiar with soils, locally adapted grasses and plants, methods of seeding, proper use of fertilizers, manures and mulches, and other related operations. This supervisor should be a man in the post engineer's organization, having the authority and ability to use initiative and ingenuity in his work.

b. Grounds-maintenance work fluctuates with the seasons, but timely attention to each problem is imperative. The grounds-maintenance supervisor and his work crew should give first priority to seasonal work. During the seasons when grounds maintenance cannot be done, the foreman and his crew can work at snow removal, drainage, improvement of roads and walks, repair of equipment, and other related jobs.

c. Because the post engineer must maintain the grounds to comply with approved standards required by the using agency, he must not only give intermittent attention to major projects, but also solve many minor problems daily. For example, the timely removal of a small amount of debris from a catch basin, a drainage flume, or a ditch during heavy rains may save the structure. He can frequently avoid high-cost reseeding by such simple actions as rotation of the areas used, timely application of nitrogen fertilizers, proper mowing, discontinuing mowing during dry periods, and proper policing of grounds.

3. Assistance from Outside Agencies

Agencies and organizations such as the Department of Agriculture, the Department of the Interior, state agricultural experiment stations, county agricultural agents, and others may be requested to assist with plans, recommendations, and specifications for grounds projects. These agencies can give valuable assistance on local problems and are usually most cooperative whenever called upon for help.

Section II

GROWING AND MAINTAINING VEGETATION

4. General

a. The grounds on posts, camps, and stations must be properly maintained to prevent dust and erosion and to improve working conditions. Special treatment is often necessary to facilitate the function of limited areas surrounding such installations as hospitals, hangars, shops, warehouses, and cantonments. Intensity and kind of traffic, intermittent or continuous use, and relation of area treated to surroundings must be considered. Adapted vegetation, if it can be grown, is the most effective and economical ground cover for immediate stabilization and permanent conservation. Whatever method is used requires timely maintenance or renewal to save labor, material, and money.

b. The maintenance of vegetated areas may include traffic control; rotation of use; mowing to stimulate density and vigor; fertilization to correct soil deficiencies; renovation by seeding or sodding; filling of rills, washes, or ruts caused by erosion or traffic; prevention of fire; watering or irrigation to promote deep root growth; control of weeds and poisonous plants; planting of temporary cover crops; use of mulching materials; and rough tillage.

5. Suitable Grasses and Legumes

The grass or other vegetation suitable for a military installation depends largely on geographical location, facilities for irrigation, and the requirements of the using service. Vegetation should be selected that is dependable, easily maintained, resistant to disease and insects, provides year-long protection, improves the area for its intended use, and suits the type of maintenance employed. The advice and assistance of trained men with local experience frequently save time and money. In planting new stands or renovating old ones, a mixture of adapted grasses of similar growth habits usually gives better results.

a. GRASSES. Grasses suitable for various areas are described below.

(1) *Kentucky bluegrass.* (*a*) *Characteristics.* Kentucky bluegrass (*Poa pratensis*) thrives in northeastern United States (fig. 1) in fertile soil that is neutral or only slightly acid. Although it may become partially dormant in hot dry weather, its dense sod provides complete dust and erosion control and greatly increases the soil's load-bearing capacity. Canada bluegrass (*poa compressa*) is sometimes preferred in the northern lake region or for poor soils.

(*b*) *Planting.* Start stands either from seed or sod. It is especially valuable for sodding such critical areas as ditch or road banks, flumes, or channels. Bluegrass and white clover make a good mixture.

(*c*) *Maintenance.* Water bluegrass infrequently, wetting the soil to a depth of 6 or 7 inches. Light watering merely stimulates growth of weeds, crab grass, and summer annuals.

(2) *Fescue grass.* (*a*) *Characteristics.* Creeping red fescue (*Festuca rubra*), chewings fescue (*Festuca rubra fallax*), and sheep fescue (*Festuca ovina*) are perennials adapted to nearly the same area (fig. 2) as Kentucky bluegrass and are especially valuable for sandy or gravelly soil. Creeping red fescue and sheep fescue have a fine, dense top growth, forming a good cover; chewings fescue does not spread but forms bunches. They are tolerant of shade, respond to fertilization, form a dense sod under favorable conditions, and are useful in grass and legume mixtures.

(*b*) *Planting.* Much of the seed is imported from Europe and New Zealand. Procure seed of good germination because the seed's viability deteriorates rapidly. Do not hold seed over from year to year. Plant early in the fall at the rate of about 30 to 40 pounds of seed per acre.

(*c*) *Maintenance.* If the grass is mowed, cut to height of 4 inches. Close mowing in dry weather weakens the grass and destroys the sod.

(3) *Buffalo grass.* (*a*) *Characteristics.* Buffalo grass (*Buchloë dactyloides*) is a hardy, sod-forming, dry-land grass adapted to the Great Plains area extending from southern Texas to the Canadian border (fig. 3). It thrives on almost any heavy soil but does not grow well in light sandy soil; it requires maximum sunlight and does not tolerate shade. Buffalo grass survives drought and spreads at the rate of about 2 feet per year.

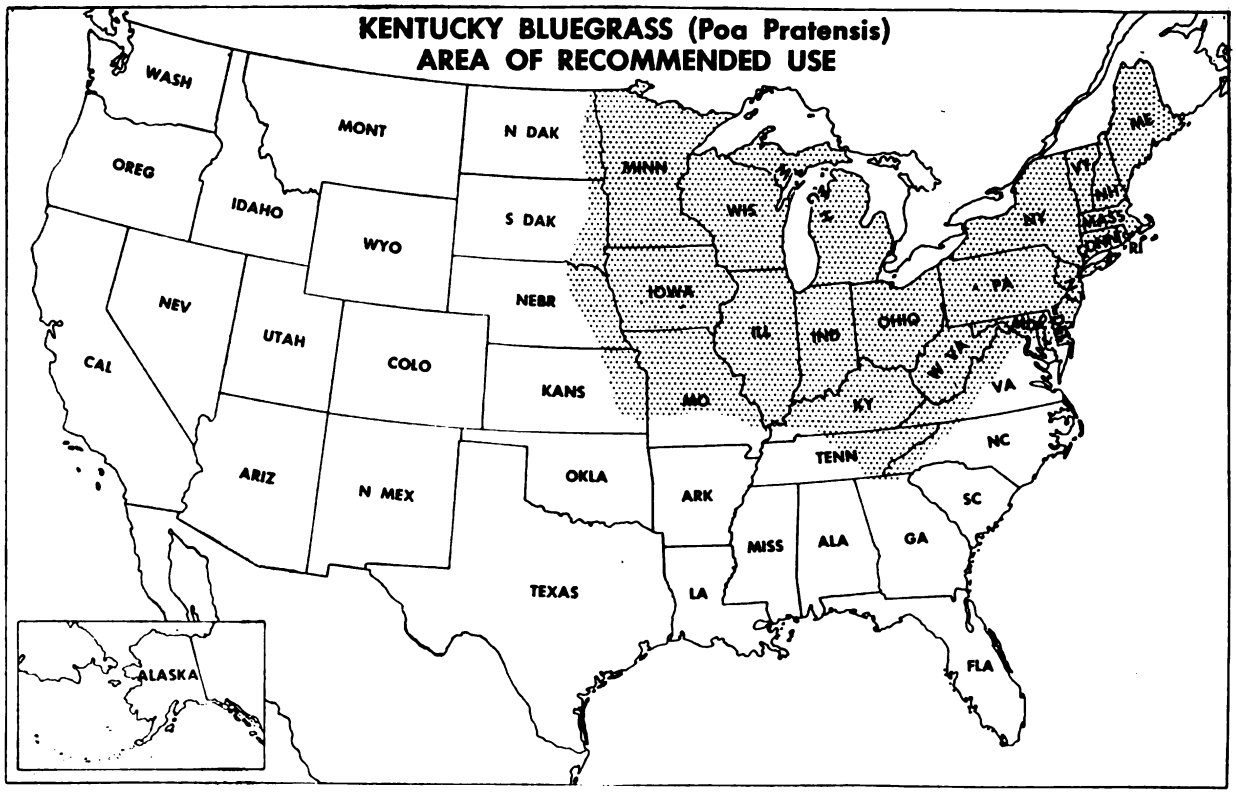

Figure 1. Kentucky bluegrass (map showing area of recommended use).

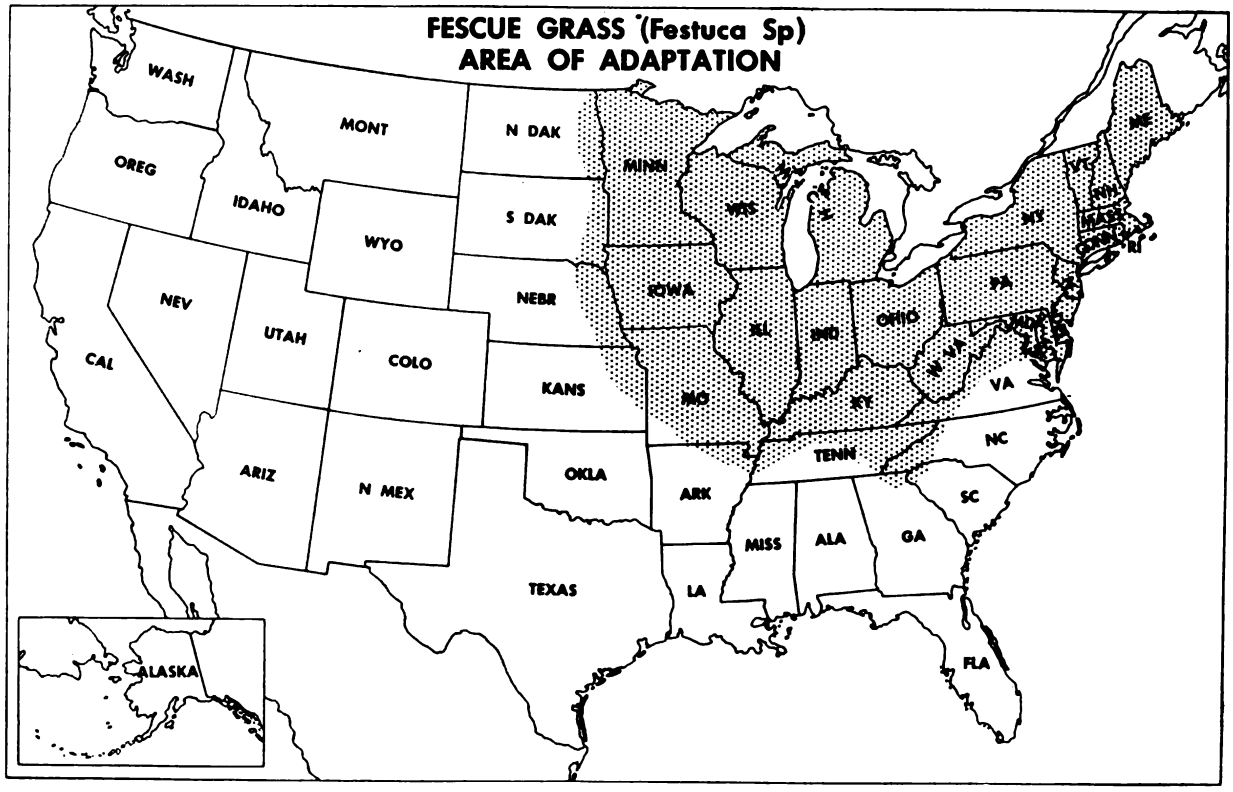

Figure 2. Fescue grass (area of adaptation)

(*b*) *Planting.* Buffalo grass can be started either from seed or sod, seeding being more economical and practical for large areas. Stabilize blowing or drifting soil before planting and until seedlings become established because the grass does not survive silt deposits or drifting dust. Use only seed that has been treated to improve germination. In mixtures with blue grama grass, which has similar characteristics, sow 8 to 10 pounds of buffalo grass and 15 to 20 pounds of blue grama per acre. Seed in spring.

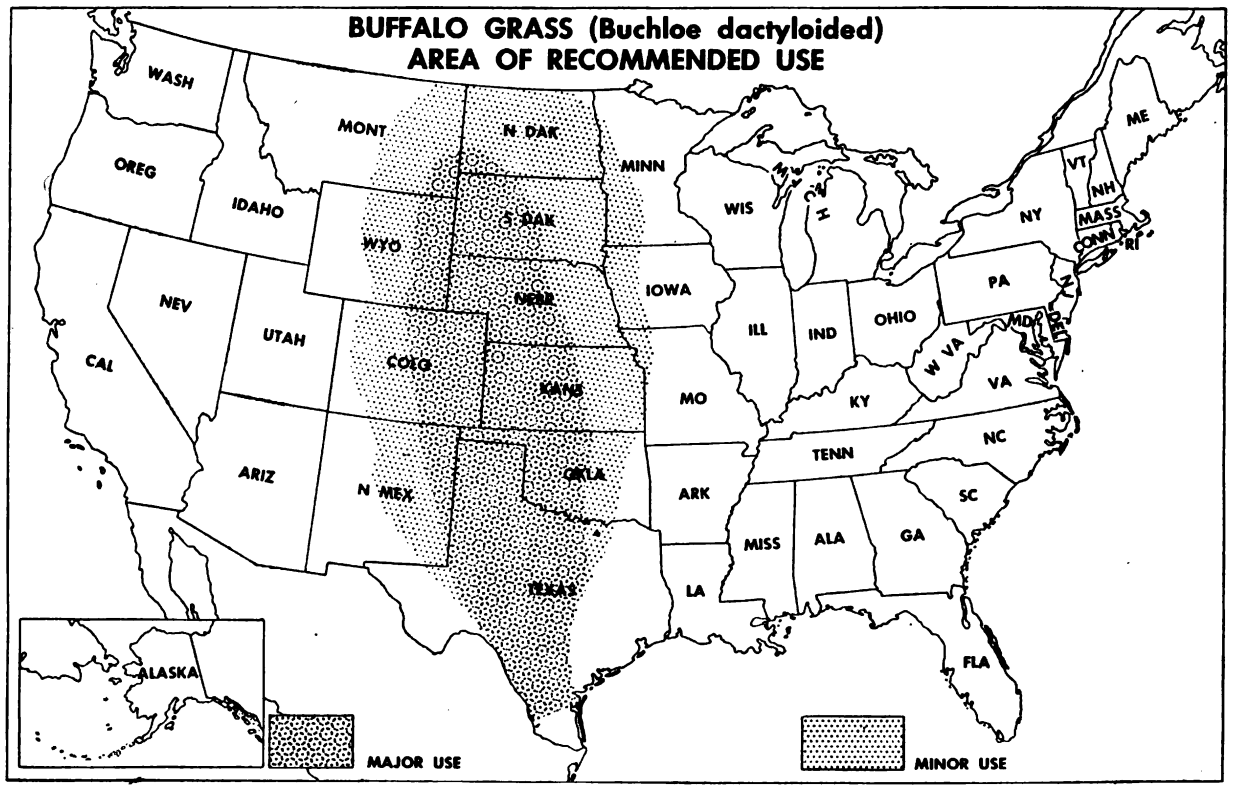

Figure 3. Buffalo grass (area of recommended use).

(*c*) *Maintenance.* Control weed and tall grass competition by frequent mowing. After a stand is established, a minimum of mowing is required.

(4) *Blue grama grass.* (*a*) *Characteristics.* Blue grama grass (*Bouteloua gracilis*) is hardy, survives in areas of light rainfall, and is naturally adapted to the Great Plains area from central Texas to Canada (fig. 4). It is normally a bunch grass, spreading only from seed, although thick stands of good sod can be produced by proper mowing. Blue grama requires sunlight but tolerates partial, intermittent shade; its growth is made in warm weather, remaining brown and dormant in winter.

(*b*) *Planting.* Plant in spring on firm soil with as shallow covering as possible. Seed covered more than ¼ inch rarely emerges. Blue grama mixes well with buffalo grass. For stands of pure grama, sow about 30 pounds of seed per acre.

(*c*) *Maintenance.* This grass does not survive heavy traffic or close mowing as well as buffalo grass. It responds to fertilization and irrigation.

(5) *Hairy grama.* (*a*) *Characteristics.* Hairy grama (*Bouteloua hirsuta*) is adapted to the same general areas as blue grama and especially to western Texas, New Mexico, and Arizona (fig. 5). Found in mixtures as far north as the Canadian border, it has a desirable, spreading, sod-forming growth. Black grama (*Bouteloua eriopoda*), another variety, has the same major area of adaptation.

(*b*) *Planting.* Because seed for both of these grasses is difficult to obtain, locate a source of supply well in advance of planting time. Seed it in the spring, sowing, mowing, and maintaining the same as for blue grama.

(6) *Bermuda grass.* (*a*) *Characteristics.* Bermuda grass (*Cynodon dactylon*) is a warm-weather grass, is not winter hardy, and is adapted to the southeastern United States (fig. 6). It forms a dense sod and spreads from roots or creeping stems that take root at the joints or nodes; it requires open sunlight and does not survive dense shade. Because this grass withstands heavy

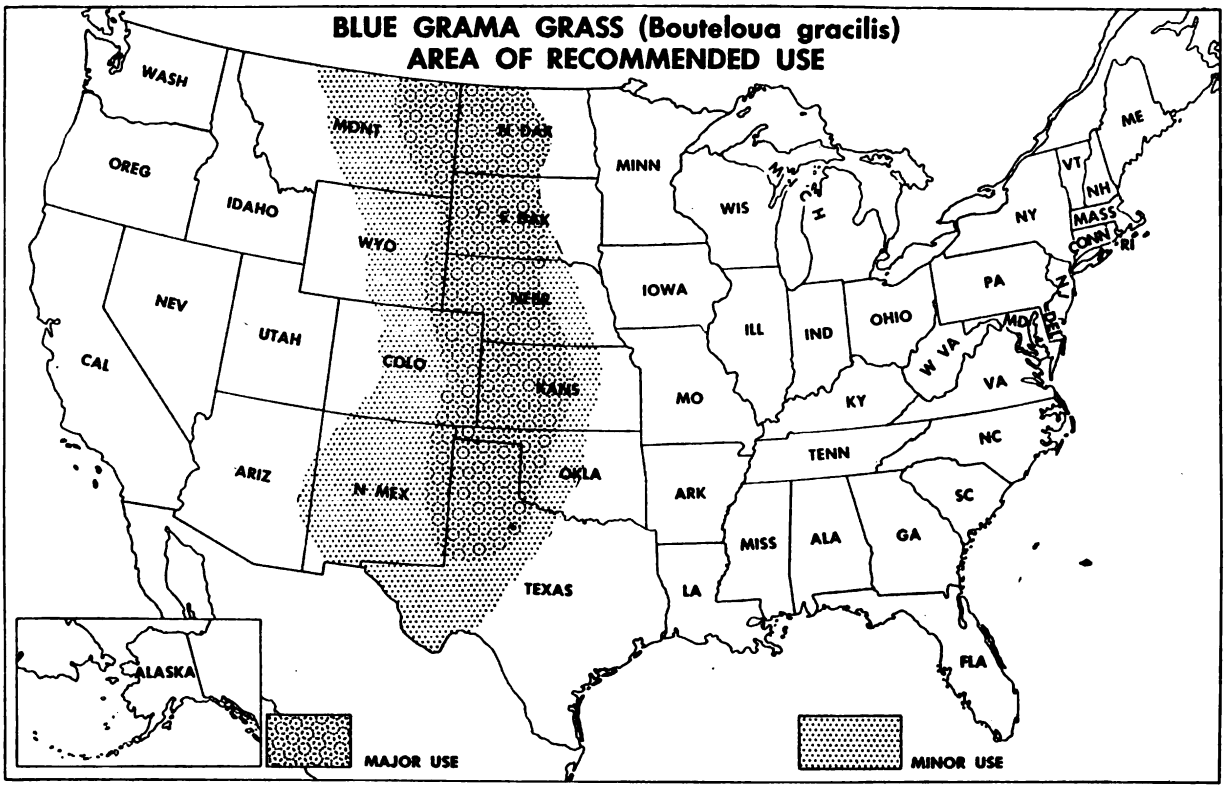

Figure 4. Blue grama grass (area of recommended use).

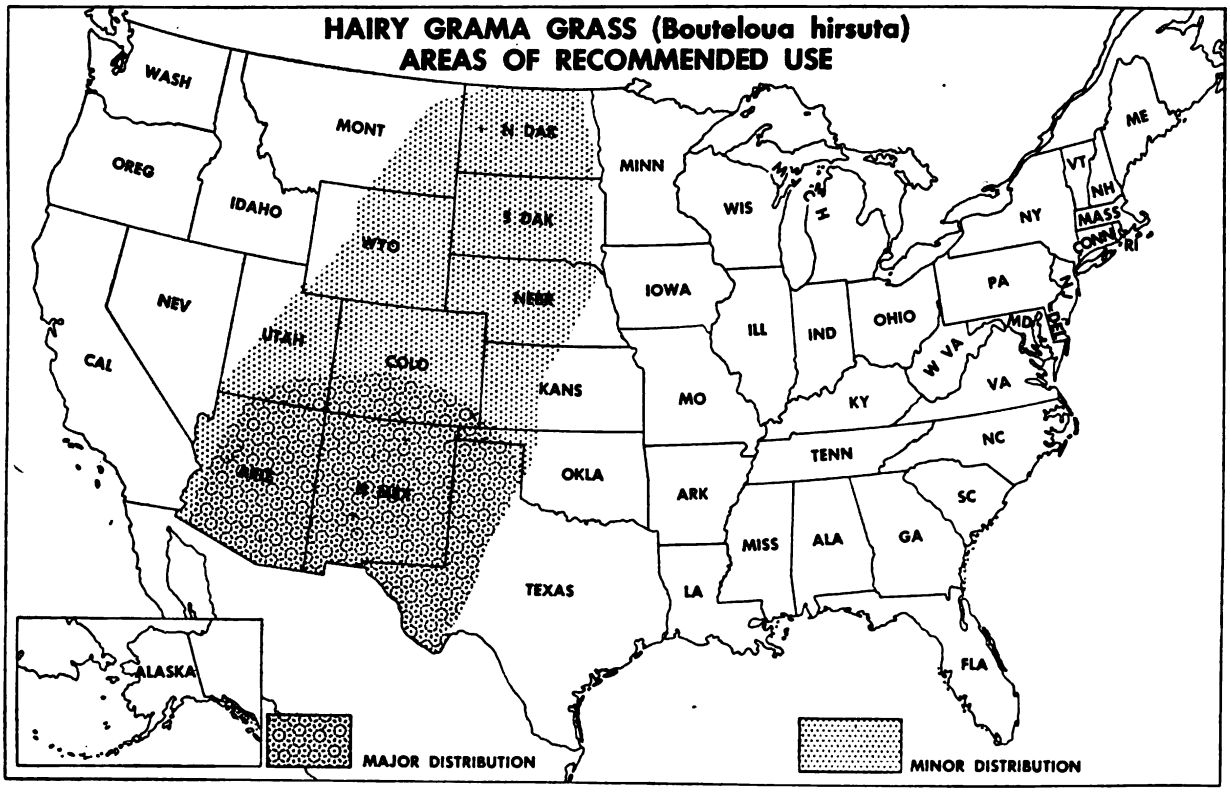

Figure 5. Hairy grama grass (area of recommended use).

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traffic, silting, and light cultivation, it is useful for airfields, drainage ways, road and runway shoulders, banks, diversion ditches, terraces, and other areas of rough usage.

(*b*) *Planting.* Good seed is produced in the extreme southwest, where the grass survives only under irrigation. It can be established by seed, rootstalks, or stolons. Use only grasses or legumes in mixture that have similar growth habits.

(*c*) *Maintenance.* Keep weeds and tall vegetation mowed, but set mower high enough to prevent cutting runners or creeping stems. Near the northern limit of the Bermuda grass area, permit a 4- or 5-inch top growth before cool weather to prevent winter damage. This grass responds to heavy fertilization.

distributed. Where a lawn type cover is wanted, the Fairway strain may be better.

(*b*) *Planting.* Ample stocks of seed are available and inexpensive. Use seed in rates to suit the area and method of maintenance. For intensive traffic areas, use 20 to 30 pounds of crested, or 20 pounds crested and 5 to 10 pounds western wheat grass, per acre; for nontraffic areas where grass density does not matter, use 8 to 10 pounds of crested and 2 to 3 pounds of western wheat per acre. If the soil has plenty of moisture and is not frozen, seed any time except late spring or early summer before August 20. Use an ordinary farm drill or grass-seed drill, drilling a little deeper than buffalo and grama grass, but usually not over ½ inch deep.

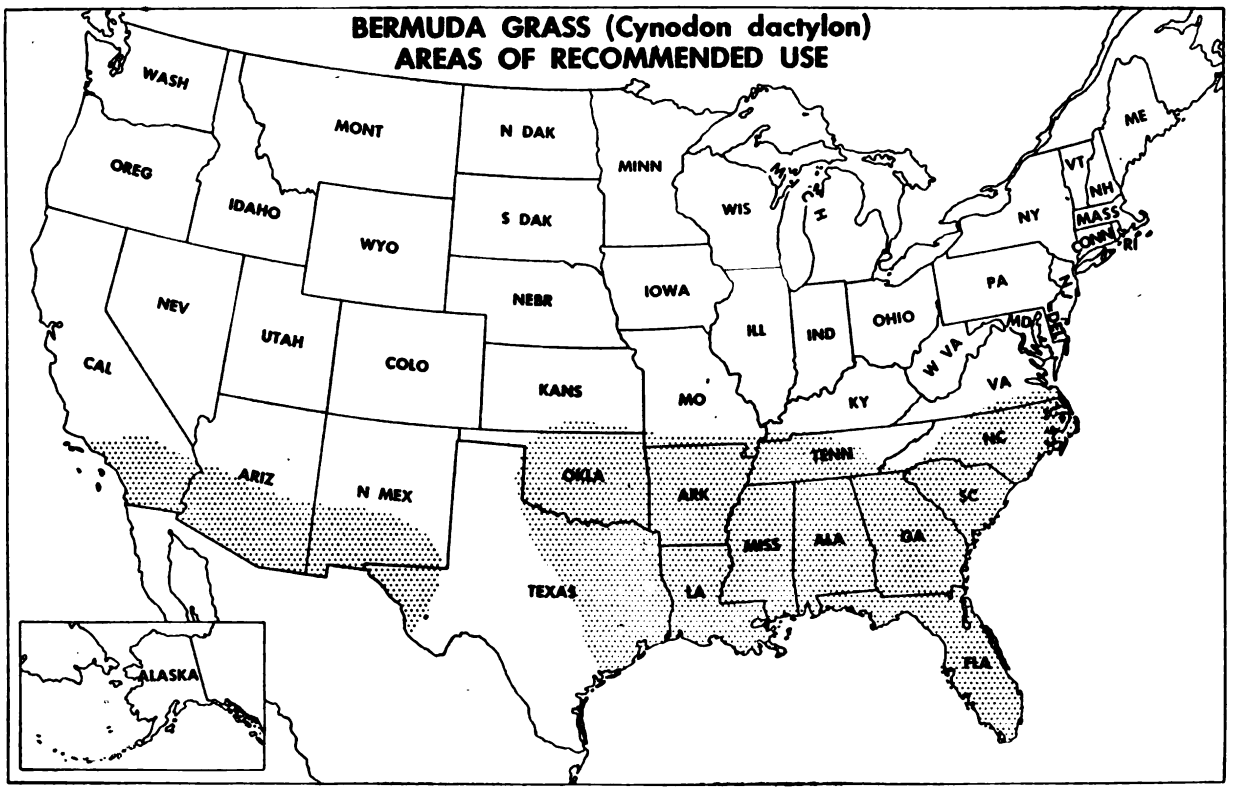

Figure 6. Bermuda grass (area of recommended use).

(7) *Crested wheat grass.* (*a*) *Characteristics.* Crested wheat grass (*Agropyron cristatum*) is a northern, cool-climate grass adapted to the light-rainfall belt (fig. 7). It grows on nearly all soils, including alkaline; it has an extensive, fibrous, deep root system to compete with weeds and other grasses for moisture and food. Of the two common strains of crested wheat, standard and Fairway, the standard strain is hardier, requires less moisture, is a little coarser, and is more widely

(*c*) *Maintenance.* Although naturally a bunch grass, heavily seeded, crested wheat grass produces a fairly dense sod if it is kept mowed about 5 inches above the ground. Where a short grass is not required, mow once each season or cut with a combine after the seed matures to reduce fire hazards and maintain proper condition.

(8) *Western wheat grass.* (*a*) *Characteristics.* Western wheat grass (*Agropyron Smithii*) is a native, sod-forming grass with both fibrous roots

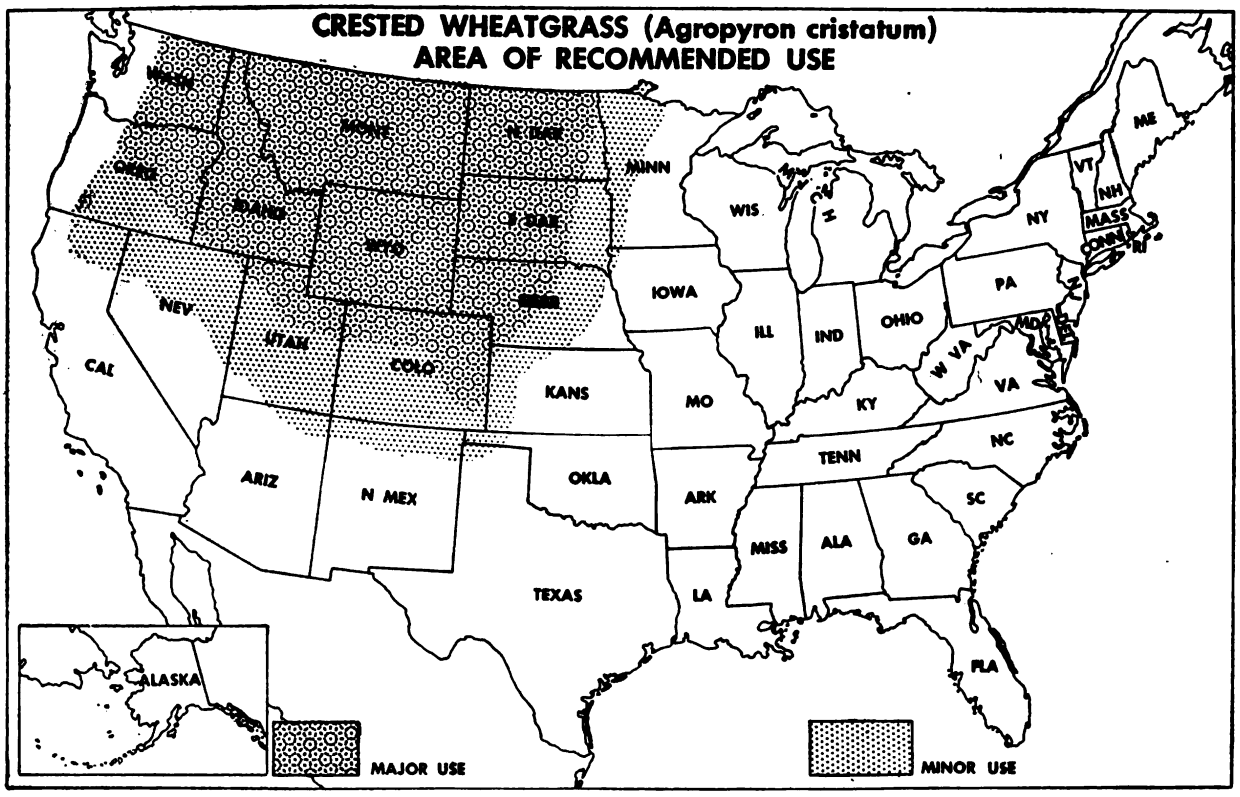

Figure 7. Crested wheatgrass (area of recommended use).

and strong, creeping rootstalks and is adapted to a large part of western United States. It is desirable in mixtures with crested wheat and thrives on heavy gumbo soils, in old lake beds and waterways, and low areas receiving extra moisture.

(*b*) *Planting.* Because seed production depends on proper moisture, obtain seed during favorable years and store for future use. Newly harvested seed is highly dormant, but percentage of germination usually increases for at least 2 years. Seed western wheat grass the same as crested wheat; plant both in a firm bed protected by a mulch. If seeded alone, sow 20 to 25 pounds of seed per acre.

(*c*) *Mowing.* At some time during its active growth, permit a good top growth. Avoid constant, close mowing.

(9) *Brome grass.* (*a*) *Characteristics.* Brome grass (*Bromus inermis*) is a sod-forming perennial adapted to the northern part of the United States (fig. 8). Selected strains are used as far south as the Ohio River in the east and northern Oklahoma in the west. It grows on almost any fertile soil having an annual rainfall of 18 inches or more; it has a long period of growth and is fire resistant most of the year.

(*b*) *Planting.* Nebraska and Kansas are the principal sources of the improved strains of seeds; Canadian-grown seed is suitable only in the extreme northern part of the country. For best results, seed in late summer or early fall. Early spring seeding can be done if weed competition can be controlled. Sow 20 pounds of seed per acre. If 3 to 5 pounds of alfalfa seed per acre is mixed with brome to improve the growth, drill in alfalfa at the same time but do not mix them in the same drill hopper. To produce a quick cover, add one-half bushel of oats per acre as a nurse crop for fall seeding.

(*c*) Brome survives heavy traffic and continuous mowing if not cut shorter than 4 inches. To fertilize brome grass, apply fertilizer in the spring and fall.

(10) *Redtop.* (*a*) *Characteristics.* Redtop (*Agrostis alba*) is a perennial, loose, sod-forming grass found nearly everywhere in the United States (fig. 9). It is adapted to wet land; is drought resistant; and can be used alone or in mixtures for seeding banks, ditches, diversions, and other areas where the moisture supply fluctuates. Redtop is short lived and not as persistent as many perennial grasses; it is usually not a strong competitor where other grasses thrive.

(*b*) *Planting.* For mixture with legumes, use

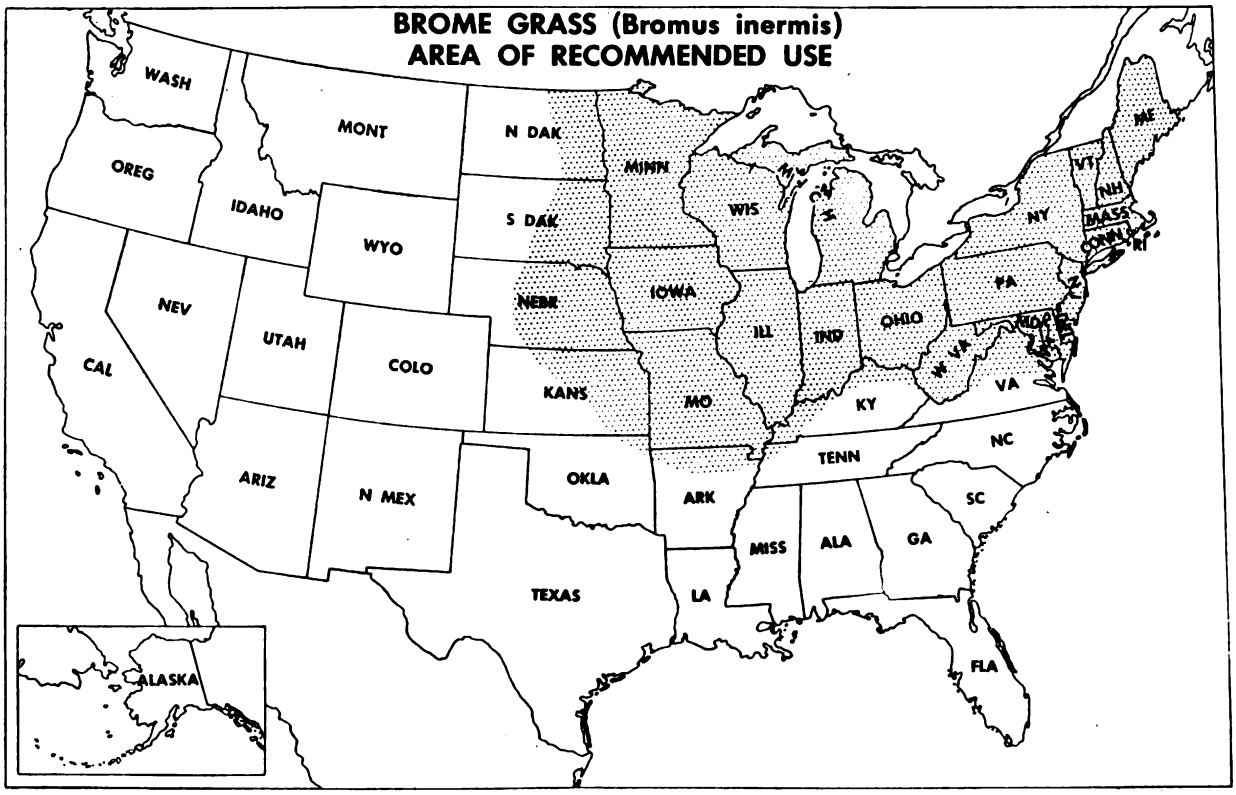

Figure 8. Brome grass (area of recommended use).

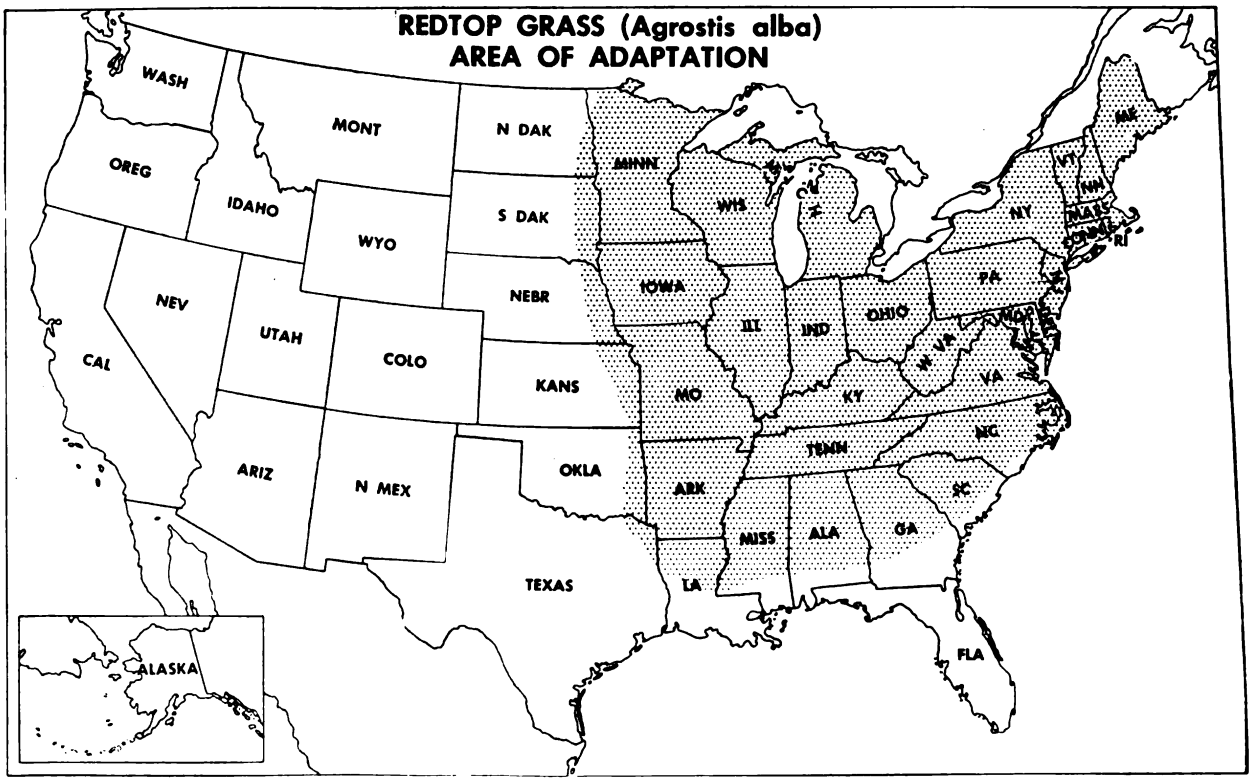

Figure 9. Redtop grass (area of adaptation).

annual lespedeza in acid soils and white clover in nonacid soils. For mixture with grasses, select those with similar growth habits such as Kentucky bluegrass, fescue, bent grass, and Bermuda. Nearly all redtop seed is produced in southern Illinois. Use 5 to 8 pounds of seed per acre in mixtures and 10 to 12 pounds if seed alone. Seed in early fall for best results.

(11) *Timothy.* (*a*) *Characteristics.* Timothy (*Phleum pratense*) is common in the northern half of the United States and grows slightly farther south at higher altitudes. It is a winter-hardy, coarse, short-lived perennial but does not produce as good sod as bluegrass, brome, or redtop.

(*b*) *Planting.* Timothy is desirable in mixtures because of its rapid germination and early growth. Seed in early spring or preferably in the fall, using 10 pounds timothy, 3 pounds redtop, and 5 to 10 pounds bluegrass per acre. Fescue grass or legumes may also be used in mixture. Seed is plentiful and easily sown.

(*c*) *Maintenance.* Timothy responds to heavy fertilization and ample moisture.

(12) *Orchard grass.* (*a*) *Characteristics.* Orchard grass (*Dactylis glomerata*) is coarse, shade-tolerant, and widely adapted in the United States, especially east of the Mississippi and north of Alabama and Georgia. Because of its bunch growth, it is not desirable where a smooth uniform sod is wanted, but it prevents dust and erosion in shady areas with minimum maintenance.

(*b*) *Planting.* This grass mixes well with alsike clover, lespedeza, fescue, or redtop. Seed it in the fall at wheat-planting time or in the spring. When seeded alone, use 20 to 25 pounds of seed per acre. To improve the cover, add 5 pounds of lespedeza in the south or 4 to 5 pounds of alsike clover in the north. A mixture of 5 pounds fescue, or 3 pounds redtop, with 18 pounds of orchard grass per acre is also desirable.

(*c*) *Maintenance.* It survives mowing and forms a dense, erosion-resistant cover if not cut closer than 4 inches.

(13) *Sand dropseed.* (*a*) *Characteristics.* Sand dropseed (*Sporobolus cryptandrus*) has some value for revegetating barren land in arid and semiarid country (fig. 10). It supplies some vegetative cover on igloos, banks, bunkers, sand blowouts, and other areas that receive only minimum maintenance.

(*b*) *Planting.* Sow broadcast in early spring or in the fall, using 2 to 5 pounds of seed per acre. Fall seedings usually do not emerge until the following spring.

(*c*) *Maintenance.* Use a light mulch of hay, grass, straw, or manure to conserve moisture and increase the growth. Commercial fertilizer is not recommended. Although it is adapted to sandy soil, it does not survive continuous mowing.

(14) *Alkali dropseed.* (*a*) *Characteristics.* Alkali dropseed (*Sporobolus airoides*) has characteristics similar to sand dropseed. It produces fairly heavy foliage, has a deep root system, and is drought resistant.

(*b*) *Planting.* This grass is easily grown from seed and is used in mixtures with crested wheat, western wheat, and the gramas to increase stand density in areas shown in figure 10.

(15) *Carpet grass.* (*a*) *Characteristics.* Carpet grass (*Axonopus compressus*) is a perennial, sod-forming grass adapted to the humid, warm areas of southeastern United States (fig. 11). It thrives in alluvial or mucky soil and survives on sandy loams and other fertile soils that are well supplied with water.

(*b*) *Planting.* Seed in early spring with 10 to 15 pounds of seed per acre. Annual lespedeza (Japan clover) and bur clover in seed mixtures usually improve new stands and reseed themselves each year until the carpet grass crowds them out. Seed is grown in Mississippi and Louisiana.

(*c*) *Maintenance.* Mow periodically except during dry weather or cool temperatures.

(16) *Bent grass.* (*a*) *Characteristics.* Bent grass is a perennial, dense, sod-forming grass adapted to cool, humid areas in New England and the extreme northwest. Several varieties, Rhode Island bent, creeping bent, and seaside bent, are tolerant of acid soil; require cool, humid conditions; and form shallow, dense spreading roots.

(*b*) *Planting.* Seed in early spring, using 40 to 50 pounds of seed per acre. In mixture with red fescue, Kentucky bluegrass, or similar adapted grasses, use 20 to 40 pounds per acre for the entire mixture. Adding 4 to 5 pounds per acre of northern-grown, wild, white clover is recommended except where pure grass stands are preferred.

(*c*) *Maintenance.* Bent grass withstands maximum mowing; it requires uniform moisture and food supply. This grass is best suited to lawns, landing strips, and other highly developed areas justifying maximum maintenance and care.

b. Grasses for Special Conditions. (1) *Reed canary grass.* Reed canary grass (*Phalaris arundinacea*) is a coarse perennial in the northern half of the United States, adapted to low, wet, swampy soils or land frequently flooded. It is not well suited to salt marshes or alkaline soil. Seed in

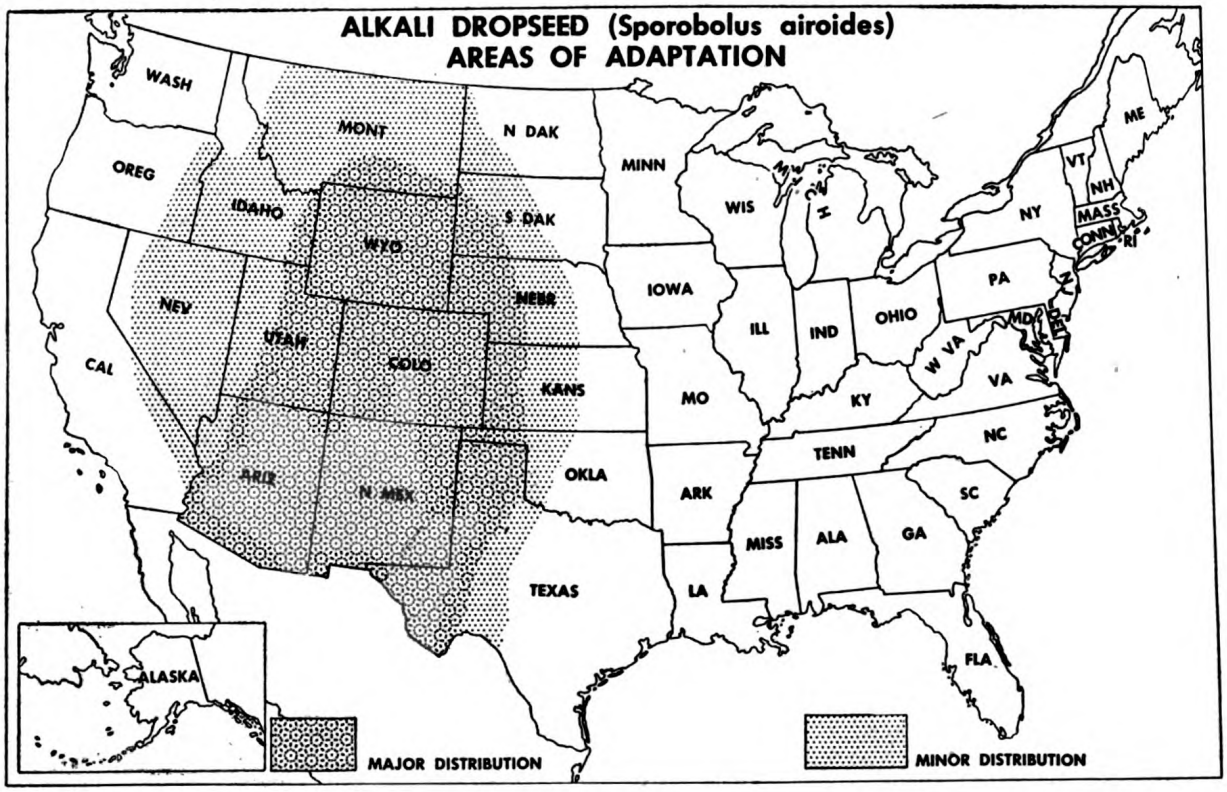

Figure 10. Alkali dropseed (area of adaptation).

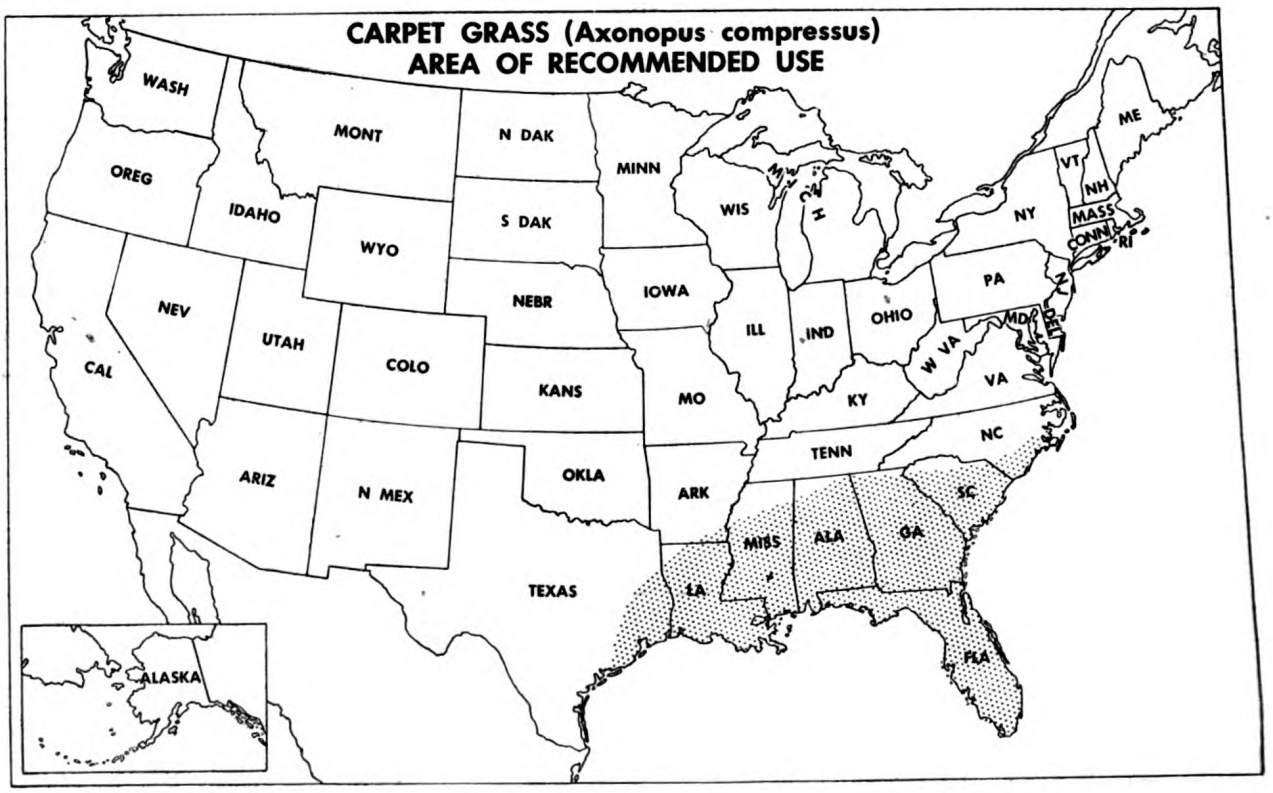

Figure 11. Carpet grass (area of recommended use).

early spring, preferably March or April, before freezing and thawing stops. In areas flooded or wet in spring, sow it in late fall or winter after growing weather has passed. Drill or broadcast 4 to 6 pounds of seed per acre; do not cover more than ¼ to ½ inch deep.

(2) *Rye grass.* Both Italian rye grass (*Lolium multiflorum*) and the so-called perennial (*Lolium perenne*) are used extensively in seed mixtures as quick-growing, temporary cover crops. Rye grass has a wide range of adaptation wherever moisture is adequate, but it should always be considered as temporary cover. In grass mixtures, do not use more than 5 pounds of seed per acre to prevent retarding the permanent grasses. Use early spring seeding in the northern states and fall seeding in the south. When seeded alone for temporary cover, use 25 to 35 pounds of seed per acre. On areas not requiring frequent mowing, rye grass under favorable conditions maintains itself for several years. Frequent, close mowing kills it in one season. Rye grass is a good substitute for permanent grasses on areas damaged by traffic or where more desirable grasses cannot grow. Seed is commercially available, and the hardy seedlings grow rapidly.

(3) *Quack grass.* Quack grass (*Agropyron repens*) is a vigorous, spreading sod-forming perennial adapted to the cool, humid part of the country. It spreads both by seed and by underground rootstocks that are difficult to eradicate once they become established. Because this grass may become a noxious weed on cultivated land, take every precaution to keep it under control. For airfields and other posts located in quack-grass areas, it can be developed into a dense ground cover better that it can be eradicated. Do not use it on areas not already infested except in remote cases where it will not spread to agricultural land.

(4) *Sudan grass.* Sudan grass (*Sorghum sudanense*) is an annual not to be confused with permanent grasses. It provides quick, temporary cover following construction and produces a desirable stubble cover in which to seed perennials. It is one of the best temporary dust-control grasses because the stubble lasts well through the second summer. It is adapted to central United States from northern Texas to Canada. For dust control or as a preparatory crop for seeding other grasses, drill 25 pounds of seed per acre between the frost-free date in spring and the middle of summer. It is killed by hard frost. Mow it to prevent seed competing with other grass the following season. Set mower just low enough to get all seed heads. Leave all residue on the ground as a mulch.

(5) *Johnson grass.* Johnson grass (*Sorghum halepense*) is similar to Sudan grass. It is objectionable on cultivated lands because it is difficult to eradicate. It grows well in southern United States but is not winter hardy. On posts already infested with Johnson grass, it can be encouraged; it should not be used in noninfested areas. It does not survive continuous, close mowing, but is usually replaced by Bermuda or Dallis grass.

(6) *Kikuyu.* Kikuyu (*Pennisetum clandestinum*) is a perennial, dense, sod-forming grass adapted to southwestern California and cannot withstand temperatures much below freezing. Surviving in areas with as little as 10 inches of rainfall, its rapid growth makes it especially suitable for preventing erosion in gullies, banks, and waterways. It supports heavy traffic and survives under continuous mowing. Its spread to cultivated lands must be prevented. It is established by planting roots, runners, or pieces of sod.

c. LEGUMES. Legumes can be best used in grass mixtures to improve the sand and supply nitrogen to the grass. On problem areas with poor soil, scalped areas, subsoil, sand-blown areas, or badly eroded and gullied areas, legumes are useful. Where time permits, using legumes to improve the soil is more economical than manure and fertilizer.

(1) *White clover.* White clover (*Trifolium repens*), also called white dutch clover or wild white clover, is a small, widely distributed clover that grows on many soils, except those extremely acid or alkaline. Because commercial seed produced in the south is not winter hardy in the north, select only acclimated stock. Seed early in spring with 5 to 8 pounds per acre. Once established, white clover seeds itself and should last for many years.

(2) *Alfalfa.* Alfalfa (*Medicago sativa*) is a perennial legume adapted to most climatic conditions and grows everywhere except the southeastern states. It requires a neutral or slightly alkaline, fertile, well-drained soil; associates well with brome grass; has a long growing season; and is fire resistant. It can be mixed with grass or seeded alone on nontraffic areas requiring minimum maintenance. Seed in spring or early fall. Use 10 or 15 pounds per acre when seeded alone or 5 pounds per acre with grasses. Alfalfa in a grass mixture can be mowed easier than sweet clover because of its upright growth.

(3) *Sweet clover.* Sweet clover is not a perennial

Table I. Grasses

Kind of seed [1]	Pounds per bushel [2]	Rate of seeding (Pounds per acre) [3]	Approximate number of seeds per pound	Federal specifications for grass seed [4]		
				Percent pure seed	Percent germination and hard seed	Percent we seed
Alkali dropseed		2–5	5, 414, 860			
Barley	48	70–120	13, 600	99	90	0.
Bent grasses	[6] 20–40	20–25	8, 164, 800	95	90	.
Bermuda grass [5]	40	10–15	1, 787, 200	97	85	1.
Black grama grass		20–30	897, 560			
Blue grama grass		20–30	897, 560	50	75	2.
Brome grass	14	20–25	136, 000	92	85	1.
Buffalo grass (in bur) [5]		8–10	49, 940	85	50	2.
Canada blue grass	[6] 14–21	50–75	2, 494, 720	80	80	1.
Carpet grass [5]	40	10–15	1, 787, 200	92	90	.
Crested wheat grass	22	20–30	192, 800	80	80	2.
Fescue, meadow	[6] 24–40	25–40	266, 720	97	90	2.
Fescues, other varieties	[6] 14–30	60–90	544, 000	97	80	.
Hairy grama grass		20–30	897, 560			
Johnson grass	28	25–30	131, 660	98	85	.
Kentucky blue grass	[6] 14–21	50–75	2, 176, 000	85	80	1.
Kikuyu grass [5]						
Millet, foxtail	48	20–35	213, 120	98	90	.
Oats	32	50–70	12, 640	98	90	. 1
Orchard grass	14	30–60	521, 600	85	85	1. 5
Quack grass [5]						
Redtop, recleaned	[6] 30–40	25–50	4, 989, 600	92	90	1. 0
Reed canary grass		4–6	544, 000	96	80	. 5
Rye	56	75–120	18, 080	97	85	. 1
Rye grasses	24	20–40	226, 720	98	90	. 5
Sand dropseed		2–5	5, 414, 860			
Sudan grass	40	20–25	54, 000	98	80	. 5
Timothy	45	8–12	1, 133, 920	99	90	. 5
Western wheat grass	[6] 14–22	20–30	138, 580	80	80	2. 0
Wheat	60	90–150	11, 330	99	90	. 1

[1] All seed purchased must comply with the requirements of Federal and State seed laws.
[2] Commonly accepted weights per bushel.
[3] Rates of seeding when planted alone.
[4] Percent live pure seed = $\frac{\text{(percent pure seed) times (percent germination + percent hard seed)}}{100}$
[5] Also propagated by planting of sprigs or stolons.
[6] High-quality seed weighs more per bushel.

and usually disappears after the second year if not permitted to reseed itself. It is a soil-building legume, sometimes used on newly graded, raw subsoil or sandy areas to control wind erosion and dust when other vegetation fails. It grows in about the same area as alfalfa but survives on slightly poorer and dryer soils. Seed early in spring or late winter with 10 to 15 pounds per acre. Do not use it in a grass mixture on areas to be mowed because of its spreading habit of growth.

(4) *Lespedeza.* Lespedeza is a legume adapted to areas with a mild climate and rainfall over 22 inches (fig. 12). Several annual varieties sold commercially as common lespedeza, Japan clover, Korean lespedeza, Kobe lespedeza, Tennessee 76 lespedeza, and so on are suitable in grass mixtures or for seeding barren areas. It tolerates acidity and grows on soil too poor to support grass. It grows north to the Iowa-Missouri line and central Illinois, Indiana, and Ohio and west to the 97° meridian. It reseeds itself each year and tolerates mowing. Another variety, *Lespedeza sericea*, is a perennial useful for erosion control and on nontraffic areas that receive minimum maintenance. Seed early in spring with 20 to 25 pounds per acre. In a grass mixture, use 10 to 15 pounds per acre.

(5) *Kudzu.* Kudzu (*Pueraria thunbergiana*) is a perennial, viny legume adapted to the southeast where the climate is warm and humid (fig. 13). Its rapid, viny growth is especially valuable for controlling erosion and preventing the spread of gullies. It provides effective protection to road banks, cuts, diversion terraces and ditches, steep slopes, and nontraffic areas requiring minimum maintenance. Establish it by planting 1- or 2-year-old crowns. For detailed information on planting, fertilizing, cultivating, and the like, consult the service command agronomist.

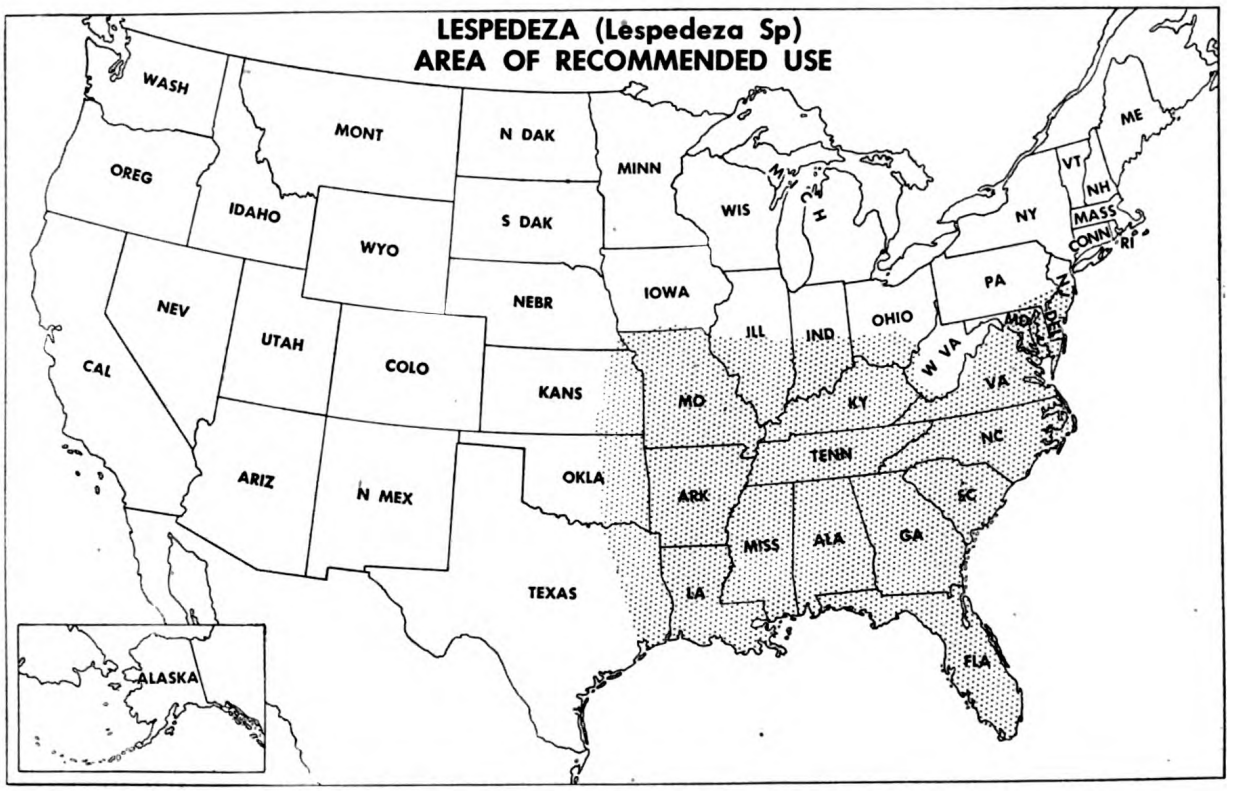

Figure 12. Lespedeza (area of recommended use).

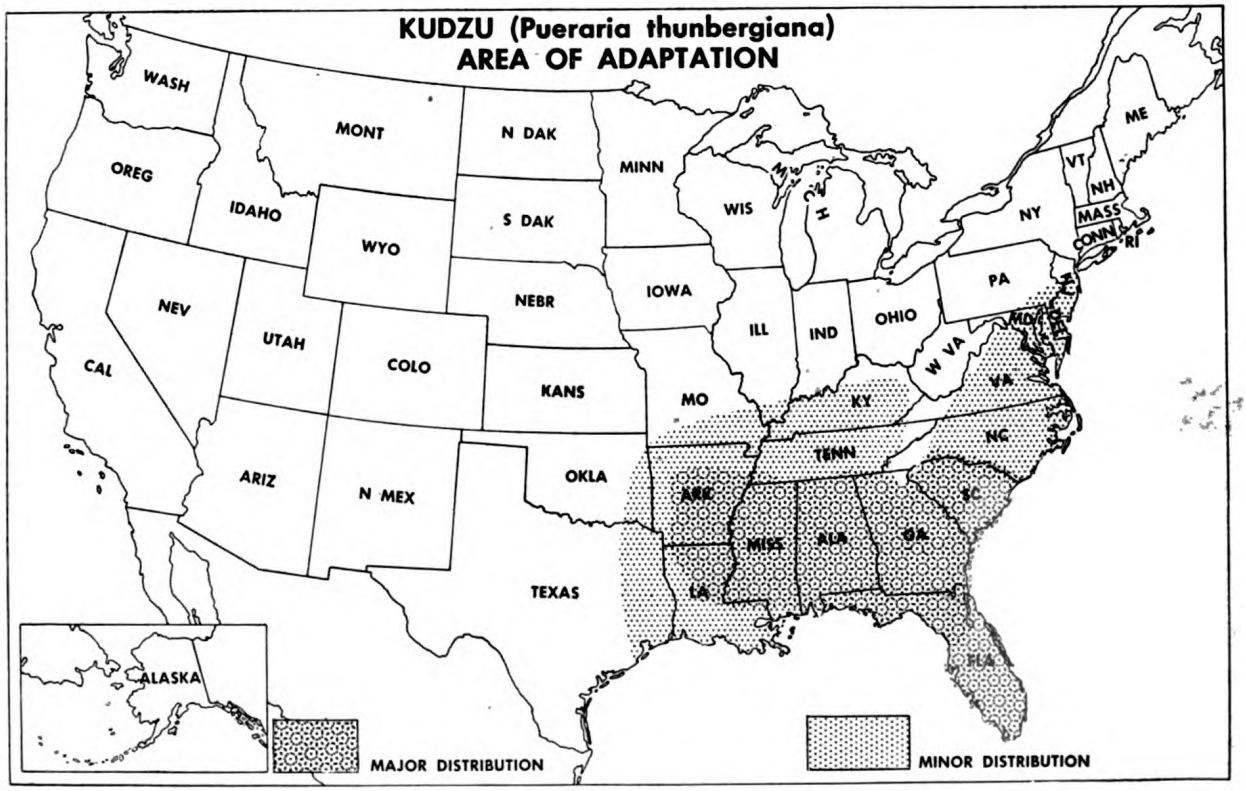

Figure 13. Kudzu (area of adaptation).

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Table II. Legumes

Kind of seed [1]	Pounds per bushel [2]	Rate of seeding (pounds per acre) [3]	Approximate number of seeds per pound	Federal specifications for legume seed [4]		
				Percent pure seed	Percent germination and hard seed	Percent w seed
Alfalfa	60	10–25	226, 720	99	90	0
Alsike clover	60	5–8	680, 320	97	90	1
Austrian winter peas	60	30–60		99	90	
Blue lupine		30–90		99	90	
Bur clover (in bur)	14	20–30		90	90	
Cowpeas	60	45–120		98	85	
Crimson clover	60	10–20	149, 600	98	85	
Crotalaria	40	10–20		99	75	
Hop clover	60	8–12	883, 600	90	85	1.
Kudzu [5]				99	70	
Ladino clover	60	5–8	680, 320	96	90	1.
Lespedeza, common	25	20–25	340, 160	96	90	1.
Lespedeza, Korean	25	20–25	238, 080	97	90	1.
Lespedeza sericea	60	10–15	372, 000	98	90	1.
Soy beans	60	45–90		98	85	
Sweet clover	60	10–25	258, 560	98	88	1.
White clover	60	5–8	680, 320	96	90	1.

[1] All seed purchased must comply with the requirements of Federal and State seed laws.
[2] Commonly accepted weights per bushel.
[3] Rates of seeding when planted alone.
[4] Percent live pure seed—$\frac{\text{(percent pure seed) times (percent germination+percent hard seed).}}{100}$
[5] Propagated by planting nursery-grown seedlings.

6. Drainage

a. Proper drainage includes the necessary filling, leveling, and grading to cause water to flow into natural or artificial waterways; it is essential not only for mosquito control, general sanitation, and protection of roads, runways, and buildings but also for growth of vegetation. Competent technicians at state experiment stations know the local problems and often advise on subsurface drainage (figs. 14 and 15).

b. Adequate drainage is especially important where roofs, roads, runways, or other structures permit great water run-off that may cause soil erosion or damage the structures. Open drainage ditches with flat slopes that can be vegetated are more economical and satisfactory than subsurface

Figure 14. Condition resulting from improper drainage.

Figure 15. Same area as shown in figure 14 after construction of sodded ditch and catch basins.

drains. Tile and underground drains should be used only to supplement surface drainage unless surface outlets cannot be found. Tile-drain outlets should be protected by head walls; open inlets must have grates and be kept free from drifting debris. The following table shows tile size required to remove ¼-inch run-off in 24 hours at various grades:

Size of tile (inches)	Fall per 100 feet (feet)							
	0.05	0.1	0.2	0.3	0.4	0.5	0.75	1
	Acres drained							
4	-----	6	9	12	14	15	19	22
5	8	12	17	21	25	28	34	40
6	13	20	28	35	41	45	56	64
8	31	43	62	75	87	98	120	138
10	55	79	110	138	158	177	215	250
12	90	128	180	220	255	280	345	410

c. Where run-off accumulates in volume, provide definite, protected waterways to carry it to the main channel. Dangerous areas usually exist at the low point in runways, aprons, around parking areas, warehouses, and storage depots. Check ditches regularly at road intersections, at the foot of slopes, and at abrupt turns near bridges or culverts. Remove debris from drop inlets and flumes. Repair rills and washes immediately to prevent gullies.

7. Establishing Vegetation

a. SOIL PREPARATION. Proper soil preparation for seeding is extremely important in obtaining a sturdy, thick sod. Initial applications of needed lime, phosphate, potash, and manure should be made before plowing or disking. In humid areas of 30 inches or more of annual rainfall, land in poor condition for seeding should be plowed, harrowed, and packed at least 2 weeks before seeding to allow the seedbed to become firm. In light rainfall areas more time is required for settling and moisture accumulation. However, light disking is usually preferable to ploughing. Unless a legume crop must be plowed under, seed can be drilled without plowing or disking if the ground is level, fairly clean, and soft enough for proper seed covering.

b. SOIL IMPROVEMENT. For soil tests, information about local soils and seeding, advice on fertilizer analyses, and the like, consult the local county agricultural agent, the nearest state experiment station, or U. S. Department of Agriculture technicians.

(1) *Soil-improving crop.* A soil-improving crop on poor soil is an excellent investment. Soy beans, annual lespedezas, cowpeas, crotalaria, and other summer-growing legumes can be planted in the spring on poor soils before fall seeding of grass. In southern states winter-growing legumes such as vetch, crimson clover, blue lupine, bur clover,

and Austrian winter peas can be planted in the early fall and plowed under just before the soil is prepared for spring seeding. In the semihumid and arid sections, Sudan grass seeded in spring or early summer, or ordinary rye seeded in the fall, may be used; grass should be drilled into the stubble without disturbing it more than necessary. Local advice is essential concerning the proper type of crop; rate, time, and method of seeding; use of fertilizers; and seed inoculation.

(2) *Lime.* Lime, essential for plant growth, gives best results if added before the soil is worked. In some localities, finely ground lime is applied with the seed. Lime requirements are best determined by soil tests.

(3) *Fertilizer.* Grass grows vigorously, dominates most weeds, and forms a dense sod if it is well fertilized. The necessary elements can easily be obtained in a complete fertilizer. For example, the formula 10–6–4 contains 10 percent available nitrogen, 6 percent available phosphoric acid, and 4 percent available potash. High-analysis fertilizers cost less per unit of plant food than low-analysis grades; the amount used per acre for grass is usually based on nitrogen content.

(*a*) Use a fertilizer drill, horse or tractor drawn, on large areas. A lime spreader designed to spread small quantities can also be used. To avoid temporary burning of foliage, apply fertilizer when grass is dry.

(*b*) Use the fertilizer recommended locally. Average applications before plowing are as follows:

1. Superphosphate, 400 pounds per acre.
2. Muriate, or sulfate, of potash, 150 pounds per acre.
3. Manure, 10 to 15 tons per acre, or activated sludge, 1,000 pounds per acre.

(*c*) At time of seeding, 200 pounds per acre of nitrate of soda or sulfate of ammonia is usually added.

c. Sodding. Sodding is much more expensive than seeding but may be necessary on such critical areas as flood-water outlets or steep slopes. Sod strips should be laid paralled to the slope, fitted snugly together, tamped or rolled to remove all air pockets, and watered frequently. The joints on alternate strips should be staggered and all holes filled with good soil. The lowest strip, or alternate strips on some slopes, may have to be pegged to hold the sod in place. A sod cutter is necessary, but no other special equipment is needed except tamping tools.

(1) Cut sod 1½ to 2 inches thick from pastures or other areas, roll it up, and lay it at once to vent drying or heating. Cut sod just thick en to have it hold together for rolling and unrol A thin sod starts growing more quickly and le the amount of material to be moved. For sod prepare soil as for seeding.

(2) For broadcast sodding with rootstalk gr such as Bermuda or Kikuyu, tear up sod t moved with a disk. Lift sod with steam sh or draglines into dump trucks. Scatter i proper area and level with a grader withou tempting to preserve the sod.

(3) A level area large enough for the p needs can be set aside as a sod nursery. enough fertilizer and lime to overcome any deficiencies, and start stands of nursery gras seeding or sprigging, depending on the typ grass used. Besides the regular local author golf-course greenskeepers can usually give valu advice about operating sod nurseries.

d. Seeding. The service command agr mist should be consulted on seed mixtures sowing densities if large areas are to be s Seed should be planted only ¼ to ½ inch deep. northern states, early fall seeding betwee August and 1 October is best, although succe early spring seeding can be done. Sout grasses should be sown in March or April. grass-legume mixtures, 30 to 45 pounds of see acre usually make a good cover. For large gr like rye grass, 35 pounds per acre; for s grasses like redtop and timothy, 10 or 15 pou The rate of seeding should be materially red in dry areas. A grass drill, grain drill with g seed attachment, or a wheelbarrow type broa seeder is needed for large areas. If the broa seeder is used, the seed should be covered wi cultipacker or spike harrow. Small areas ca planted with a hand-operated whirlwind seed the seed is covered with a corrugated or perfor roller. A smooth, packed surface may for crust through which seed cannot grow.

e. Protection of Seedings. On poor s slopes, and eroded areas, a very light mulc straw, hay, or manure should be added imm ately after seeding for protection. Using 1 tons per acre so the bare soil can still be protects the seed from washing, the soil becoming dry, and insures a stand of grass.

f. Seed Mixture. In selecting the proper mixture, growth characteristics of the grasses legumes, soil types, and climatic conditions considered. Local recommendations of the s ice command agronomist or agricultural te

cians must be followed. The maps referred to in paragraph 5 show regions of adaptation. In addition to the legumes discussed in paragraph 5, others of value for erosion control, or for starting a stand on areas other than airfields, include alsike clover, hop clover, bur clover, and ladino clover.

g. EQUIPMENT. The following equipment is necessary where extensive areas of grass are to be maintained:

(1) Small, rubber-tired tractor with proper attachments.

(2) Moleboard plow with tractor hitch, 12 or 14 inch.

(3) Two-section spike-tooth harrow with tractor hitch.

(4) Disk harrow with tractor hitch, 7 or 8 foot.

(5) Tandem cultipacker with tractor hitch, 8 or 10 foot.

(6) Grass drill with fertilizer attachment, or grain drill with grass-seed and fertilizer attachments, with tractor hitch.

(7) Lime distributor or fertilizer spreader with tractor hitch.

(8) Manure spreader with tractor hitch.

(9) Wheelbarrow type seed broadcaster, hand-operated.

(10) Cyclone type hand seeder.

(11) Corrugated or perforated roller, hand-operated.

(12) Sickle-bar type mowing machine with tractor hitch.

(13) Hay rake with tractor hitch.

(14) Power-driven lawn mower.

(15) Pickup or ½-ton truck.

(16) Hand tools such as hoes, rakes, shovels, and the like.

(17) High-speed gang mower with towing hitch.

8. Revegetation

Vegetation damaged or destroyed by intense traffic, fire, floods, or drought requires replacement or repair. Usually the original vegetation is replaced unless experience has indicated that some other type would be better. Revegetation of a few acres can usually be done by direct seasonal planting or seeding without special treatment. Larger areas subject to washing or blowing may require a temporary cover crop before permanent grasses are seeded. An anchored mulch to stabilize the soil and protect the seedlings may be necessary. Areas destroyed by fire, oil, or chemicals may need soil renovation by crops of rye, oats, barley, or Sudan grass or by an organic fertilizer. Seed-bed preparation, time and rate of seeding, fertilization, and early maintenance, especially traffic control, are the same as for original vegetation. For traffic control, see paragraph 15.

9. Improvement and Maintenance

To maintain proper vegetation, the post engineer and his staff must be guided by several factors. In general, plant growth depends on a satisfactory balance of plant food, soil moisture, temperature, and light.

a. Limited top growth means a weak root system susceptible to weather and insect damage.

b. Total rainfall, sunlight, and air temperature cannot be artificially controlled, but soil moisture available to plants, soil temperature, and effective sunlight can be favorably influenced by proper drainage, vegetative cover, organic mulches, and timely mowing. Growing vegetation or artificially applied mulch reduces the rate of run-off, increases the rate of infiltration, and insulates the soil from intense heat. Control of weeds and tall vegetation by proper mowing permits sunlight to reach desirable sod-forming grasses.

c. Plant-food deficiencies can be overcome with the necessary fertilizer or soil correctives after soil tests.

d. If water is easily available, supplemental irrigation can be used in limited areas during critical periods. One inch of water, 27,000 gallons per acre, wets average soil 6 or 7 inches deep.

e. Maintenance procedure in each area varies with soil differences, organic matter, fertility, traffic, water supply, etc.

f. Nitrogen is the most important element affecting the vigor and rate of growth. Two applications a year, early in spring when growth starts and in the fall just before growth stops, are best for grass. Under humid conditions, 100 to 125 pounds per acre per year can be used, while in semihumid areas, possibly 60 to 90 pounds per acre may be the top limit. Ammonium nitrate (33 percent nitrogen), nitrate of soda (16 percent nitrogen), and other commercial forms are available from the Ordnance Department. Sewage sludge, compost, and other forms of organic nitrogen may be used as top dressing for grass and other vegetation.

g. If soil tests or experience indicate phosphate shortage, super phosphate, not readily soluble, can be applied infrequently in large amounts. Depending on needs, 400 to 800 pounds per acre can be drilled or broadcast while the grass is dormant. If drilled in early spring, it should be placed as

deep as possible. Phosphates usually stimulate legumes which lessen the need for commercial nitrogen.

h. Acid soils with a pH of 6 or lower may require lime.

i. Potash is usually not essential to good cover although some soils may be deficient enough to justify its use. It can be supplied in a complete fertilizer, muriate of potash, or other commercial form. Potash is soluble being carried into the soil with rainfall.

j. Traffic control and timely mowing are other important steps under the direct control of the post engineer.

k. The fertilizer used must have an analysis to suit the soil deficiencies. The following shows how the common fertilizers are applied:

Analysis of fertilizer	Pounds per acre	Time of application	
		Northern States	Southern States
6-8-4	700	September	March.
5-10-5	800	September	March.
10-6-4	400	September	March.
10-20-0	400	September	March.
16 to 20 percent nitrate of soda	200	September and April	March.
20 to 22 percent sulphate of ammonia.	200	September and April	March.
33 percent Ammonium nitrate.	100 to 150	September and April	March.
Activated sludge	1,000	September and April	March.
Manure	10,000to 20,000	Winter	Winter.

10. Mowing

Routine mowing is essential on nearly all posts. Bar mowers, designed for tall vegetation, should not be driven faster than 4 miles an hour; reel type gang mowers, designed for short vegetation less than 10 inches high, can travel at 8 to 12 miles an hour depending on grass density and smoothness of the ground (figs. 16 and 17). Large gang units covering a wide swath are much more economical of man or tractor hours. Mowing machines are simpler than other post equipment, but they must be given constant, delicate adjustment for efficient operation and long service.

a. The primary objective of mowing is not beautification but maintenance of a desirable, permanent, vegetative ground cover to improve the area for its intended use. Mowing is governed by type of vegetation, season, soil, and rainfall, not by convenience to other jobs on the post. Proper mowing increases density and vigor of the grass, retards weed growth, and develops tough sod with maximum load-bearing capacity.

b. Grass that is shaved off close to the ground is almost sure to die or be crowded out by crab grass, weeds, and summer annuals. Ordinarily 3 or 4 inches of top growth, more in dry areas, is needed to nourish the root system, keep soil temperature down, prevent excessive run-off, reduce evaporation, prevent dust and erosion, and provide the best wearing surface. Isolated areas in weeds, grass, or hay crops should be mowed to reduce the fire hazard and improve the cover. Weeds should be mowed before seed develops.

11. Weed and Poisonous-plant Control

Weed control is not a serious problem on most posts. A weed cover may prevent dust and erosion and help in establishing a stand of permanent grass in light rainfall areas. Weeds should not be permitted to spread, but complete eradication of nonpoisonous species is rarely necessary. Of the many common weeds in the United States, about half are annuals, the roots living but 1 year, and half are biennials or perennials, the roots living 2 or more years. Noxious weeds are usually creeping perennials spreading from roots or seed and are extremely difficult to kill. State experiment stations can advise on control methods and state laws governing noxious-weed control.

a. Control by Mowing. Most annuals and a few perennials can be killed by mowing just as the blossoms begin to open. Because they blosson at different seasons, mowing twice a year, Jun and August, is usually necessary. Weeds lik wild carrot in the North and bitterweed in th South send out flat-lying, secondary, flowerin shoots from the stubble. Such weeds should b cut high (8 inches) the first time and low (3 inche the second time to remove the secondary shoot

b. Control by Chemicals. Although wee killing chemicals or herbicides are expensive a may be dangerous, they are useful on small are for killing individual plants or groups of plants for keeping down all vegetation on railroads, driv ways, oil-tank fields, transformer stations, ra towers, lumber yards, fire guards, and simi places.

(1) Ammonium sulfamate is a good spray cause it does not injure the soil or the bark trees and large shrubs. It is neither poisonous inflammable. It should be applied to the surface in solution (12 ounces per gallon of wat after the plants have completed growth, pre ably in September and October. Sodium c rate also kills creeping perennials and other we

Figure 16. Bar mower, designed for tall vegetation.

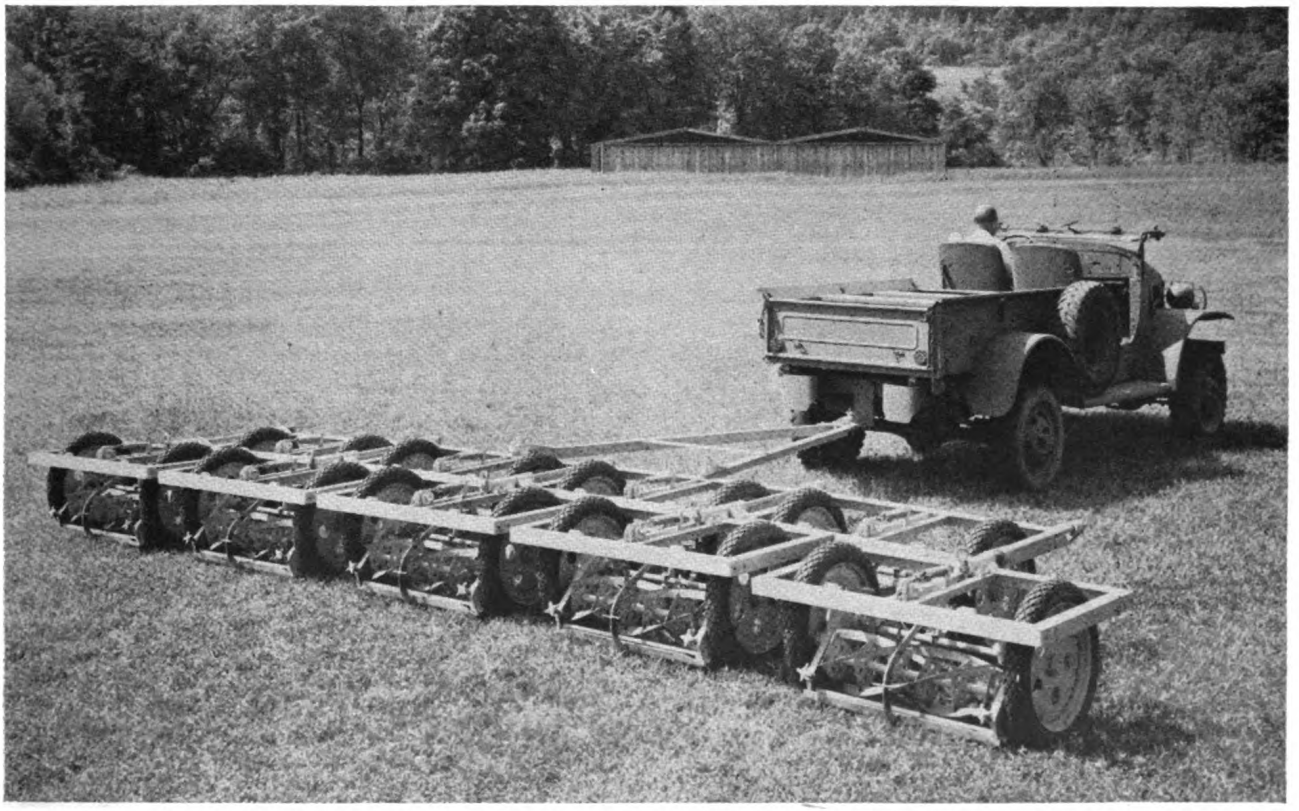

Figure 17. Reel type gang mower for short vegetation.

but it is inflammable when mixed with organic material and must be used with caution.

(2) Sodium arsenite, dry or in solution, is a standard soil sterilizer. Applications of 3 to 6 pounds per square rod act quickly and last for many years. Several other chemicals such as sodium chlorate, borax (or boric acid), common salt applied at rate of 150 to 250 pounds per square rod, Diesel oil, fuel oil, or waste oil can be added to the soil to kill vegetation, but they are not as effective as sodium arsenite.

Caution: Sodium arsenite is a poison. Animals should be kept away from treated areas until rain has carried the chemical into the soil. Personnel applying sodium arsenite should wear suitable overalls, gloves, and masks. Sodium chlorate in the dry form is inflammable.

c. Control by Burning. Burning over areas to control vegetation should be avoided because destroying the organic matter lowers soil fertility. Repeated burning may destroy vegetation to such an extent that dust and soil erosion are intensified.

d. Eradication and Control of Poison Ivy. (1) Poison ivy (oak) plants (fig. 18) are recognized by their leaves which are always divided into three leaflets having a shiny, polished appearance. It is a native perennial spread by seeds and root stocks and is common throughout the humid sections of the United States. It occurs as an erect and bushy shrub, as a prostrate and trailing vine and also as a long, woody, tree-climbing vine. Its nonvolatile, oily poison is found in all parts of the plant, not only in the growing leaves but even in the seasoned wood. Poisoning is usually caused by touching or brushing against the plants or by handling clothing or other articles that have been in contact with them. Smoke from burning plants also carries the poison. Control by grubbing is effective and permanent if properly done. Dried roots and stems should be burned and care taken by workmen to prevent contact with the skin and to avoid the smoke of burning plants. Another way to kill poison ivy is by spraying the foliage with one of the following:

(*a*) Sodium chlorate, 1 pound per gallon of water.

(*b*) Sodium arsenite, 8 ounces per gallon of water.

(*c*) Fuel oil or waste motor oil.

(*d*) Ammonium thiocyanate, 1 pound per gallon of water.

(*e*) Borax spread dry at 8 to 10 pounds per square rod.

(*f*) Ammonium sulfamate, 12 ounces per gallon of water.

(*g*) 2,4-dichlorophenoxyacetic acid, 1 ounce to 5 gallons of water.

(2) Ammonium sulfamate, the most efficient chemical, should be sprayed on the plant foliage. The sprayer should be washed carefully with water after ammonium sulfamate is used to prevent corrosion of galvanized metal. Its chemical action is slower than other common herbicides. The toxic effect may not be seen for more than 24 hours after treatment, and plants may not appear dead for a week or more. A second treatment is usually advisable after several weeks to treat plants overlooked or new shoots sent up from the roots. Spray treatment between 15 May and 15 August, before plants go into dormancy, is effective.

12. Airfields

Unpaved areas of airfields require as definite maintenance as runways, roads, buildings, and other structures. Proper maintenance eliminates the dust hazard, prevents erosion, and protects the field surface for traffic. The use of various parts of the field influences the type and intensity of maintenance needed. Perennial grass is the best ground cover for fields if it can be established. The dust-control measures installed originally determine the type of maintenance as long as they are satisfactory.

a. Select grasses for airfields that are adapted to local conditions and locally available as sod, sprigs, or seed. Grass must survive local extremes of heat, cold, and drought without artificial irrigation. It must form a tough permanent sod capable of heavy wear. It must survive on poor soils, withstand periodic mowing, be easily repaired, prevent erosion, and permit adequate drainage.

b. During airfield construction, perform the operations that simplify future maintenance if possible. To permit rapid drainage from runway and other hard surface areas, grade shoulders to a slope of 2½ inches in the first 4 feet before starting vegetation. Install lighting, provide drainage channels and outlets, and do all necessary leveling before seeding. During the grading and leveling operation, leave the best soil on the surface rather than in the bottom of the fills.

c. Take special care of newly sodded or seeded areas during the early stages of development,

Figure 18. Poison ivy (oak) plant.

restricting traffic and mowing to prevent weed competition.

d. After each rain, take steps to prevent development of rills and gullies in grass areas providing run-off for runways and other hard surfaces. These shoulder areas, in addition to receiving large amounts of run-off, are also subjected to propeller blasts which cause trouble in parking areas, warm-up areas, and on curves. Well-established grass 4 to 6 inches high provides ample protection but temporary aid from mulching material held in place by rod-and-bar mats or woven wire may be necessary for dust control. Cut-back asphalt, road oil, or coarse gravel must be used if grass alone does not hold.

e. Grass cannot ordinarily be maintained in parking or work areas. When parking planes on grassed areas is necessary, tow them to the apron before servicing. Confine gasoline transports to traffic areas. On grass landing fields without runways rotate use of areas to give the grass time to grow. Set mowers high enough to form a good cover and produce a shingle effect against air blasts and landing wheels. Top-dress grassed landing fields with manure and commercial fertilizer wherever necessary to get a uniform, vigorous growth. Mow field uniformly to encourage rotation of use.

13. Athletic Fields, Drill and Parade Grounds, and Ranges

Adequate facilities for recreation, training, and practice are necessary for both morale and efficiency. The post engineer is responsible for

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dust control and general maintenance of the installations required by the special services officer. Figures 19 through 30 show typical lay-out diagrams and construction details for recreation facilities.

a. MAINTENANCE OF GRASS COVER. Grass cannot be maintained beyond definite limits of use or intensity of traffic. If traffic on a limited area must be so intense that grass is destroyed faster than it can grow, other dust-control measures should be substituted. Where grass can be used, however, it is the most economical and satisfactory cover. Its maintenance is essentially the same as that prescribed for lawns (par. 14). The heavy-duty vegetation for recreation fields requires careful management and treatment.

(1) *Fertilization.* Procedures for proper fertilization are given in paragraphs 7 and 9.

(2) *Liming.* Make acidity tests the same as for commercial fertilizers and apply the amount necessary. For high acidity, use as much as 50 pounds per 1,000 square feet if necessary. For best results, add lime before seeding, working it into the seed bed.

(3) *Rolling.* Roll grassed recreation areas early in spring when the soil is not too wet. A 400-pound hand-operated roller is a most efficient tool for this purpose. On large areas, a tractor-drawn land roller can be used.

(4) *Mowing.* Do not ruin good cover on recreation areas by close mowing. Leave mower clippings on the area to benefit the sod. (See par. 10.)

(5) *Watering.* If watering facilities are available, water thoroughly during dry weather at weekly intervals to encourage the roots of the desirable grasses. Wet the soil at least 6 inches deep. Light sprinkling stimulates the growth of weeds and crab grass.

(6) *Top-dressing.* Top-dress cover on recreational areas with rich topsoil or compost every 2 or 3 years. Add top-dressing to a depth of about ¼ inch. Top-dressing also makes a smooth surface and eliminates bare spots.

(7) *Revegetation.* Revegetate recreation areas becoming barren because of abuse and mismanagement. (See par. 8.)

b. SAND-CLAY SURFACES. The sand-clay surface is particularly adapted to tennis, roque, badminton, and paddle-tennis courts. A clay surface suffers from frost upheaval because it traps and holds water. Courts should be closed during winter when this reaction occurs. To recondition sand-clay surfaces at the start of the playing season—

(1) Sweep off all sand, stone, or other loose material.

(2) Work when the surface is dry, or nearly dry, and complete the job before rain sets the surface. Plan work according to the size of the area and the working crew.

(3) Rake the surface to cut down high spots and work material into low spots. Add material if necessary.

(*a*) Use a wood close-tooth lawn rake for fine raking.

(*b*) Check surface for high and low spots with a board straight-edge.

(*c*) To get a smooth surface, use an improvised board-rake approximately 3½ feet wide.

(*d*) Roll and rake or straightedge alternately until a smooth, even surface is obtained.

(4) Sand or stone-dust screenings may be needed if a blue clay, or similar clay, that sticks to the roller has been used.

(*a*) If surface is to be sand covered, use a sharp, fine sand. Do not use beach sand because the round particles roll, producing a slippery surface.

(*b*) Use colored stone-dust screenings, if they can be obtained cheaply, to produce a contrasting surface color for white lines and to reduce light glare.

(*c*) In using stone-dust screenings on tennis courts, remove coarse particles affecting ball rebound.

(*d*) Avoid thick coatings which pile up and make an uneven surface. More than 2 yards of sand or stone dust should not be needed to cover a tennis court.

(5) Soak surface thoroughly and roll before it becomes thoroughly dry to pack the clay and roll out the high spots. In turning a hand roller, do not dig up the surface. Require men to wear tennis shoes or rubbers to prevent damage from hard heels.

c. MAINTENANCE OF SAND-CLAY SURFACES. Sand-clay surfaces require considerable daily maintenance depending on use. Much damage can be prevented by closing courts to use when they are wet and soft and by requiring players to wear tennis shoes.

(1) For daily maintenance of tennis courts, follow these procedures:

(*a*) Smooth surface with a drag made from a cocoa mat or old carpet, a board straightedge rake, a heavy push broom, or a stable broom.

(*b*) Water and roll as needed.

(*c*) Clean off canvas-tape lines or replace chalk-

dust or whitewash lines as necessary. Commercial hand-operated machines are available for applying these lines.

(2) For periodic maintenance of sand-clay surfaces, follow these procedures:

(*a*) Treat with weed killer if grass growth justifies it. Pull out occasional grass manually.

(*b*) Treat with calcium chloride to prevent dust and damage to surface. Some clays require more frequent treatment than others.

(*c*) Add sand or stone-dust top dressing as needed.

(*d*) Check ditches and other drainage facilities.

(3) To mark off courts, use one of the following methods:

(*a*) Use chalk or lime dust for dirt, clay, and turf surfaces.

(*b*) For dirt and clay surfaces which do not have loose material over them, use a lime solution.

(*c*) Line bituminous surfaces with asphalt-base aluminum paint or traffic paint.

(*d*) Line concrete surfaces with a contrasting-color traffic paint.

(4) Several oil dust palliatives may be used to control dust on athletic areas and parade grounds. (See par. 23.)

d. Lay-outs for Recreational Areas. Diagrams of lay-outs for various recreational games are shown in figures 19 through 30. Dimensions and construction details are included.

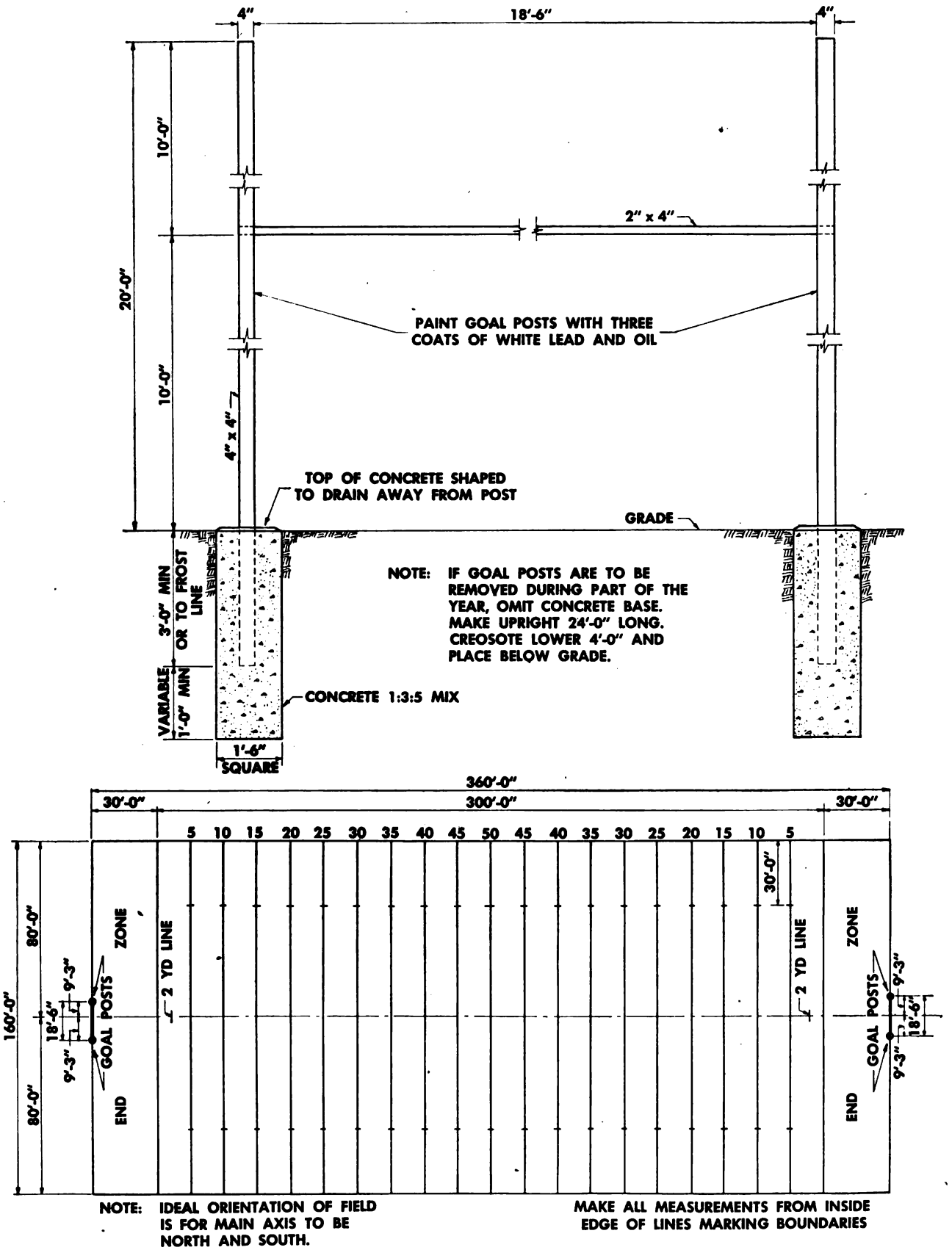


Figure 19. Football field.

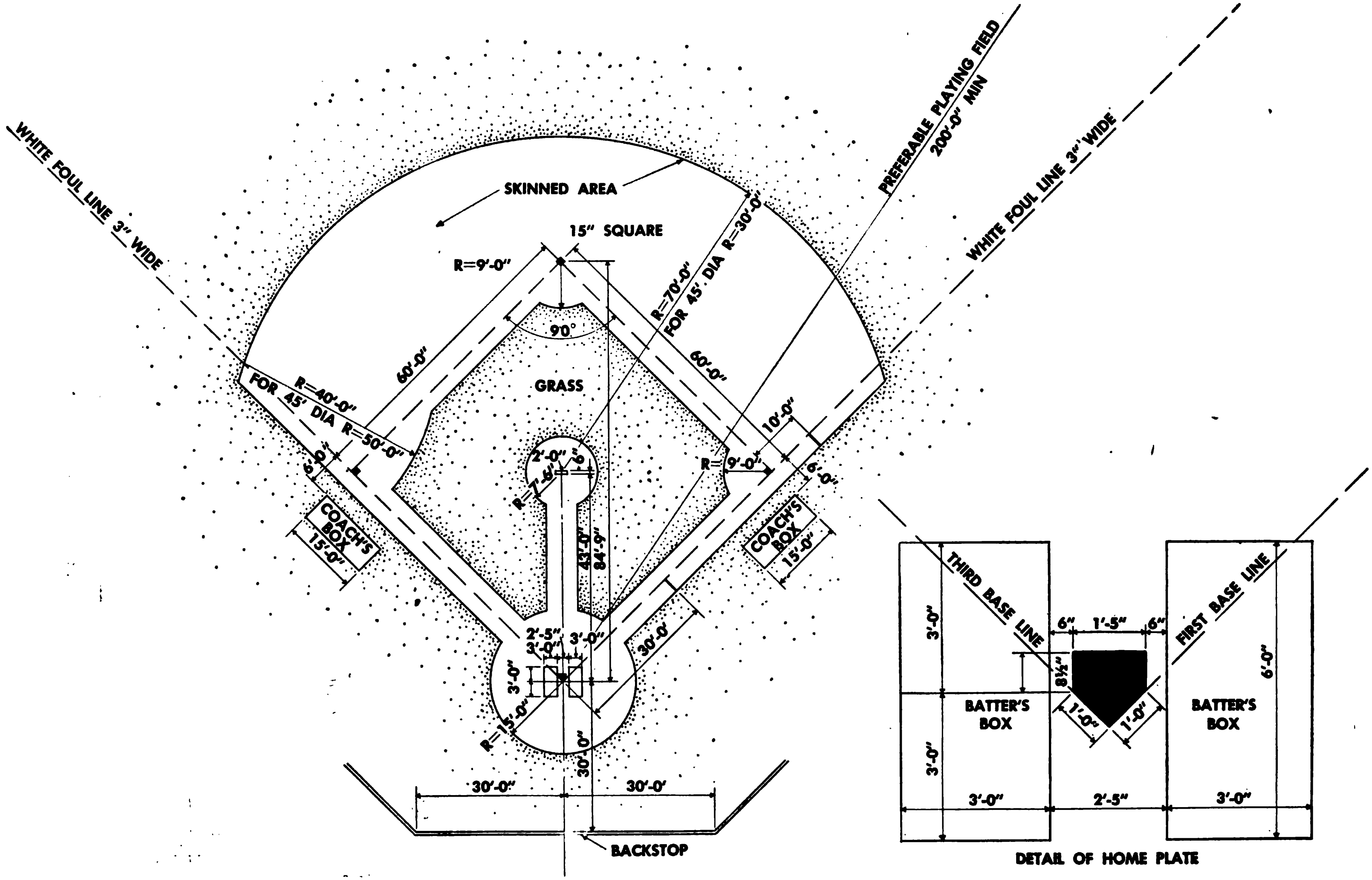


Figure 20. Softball diamond.

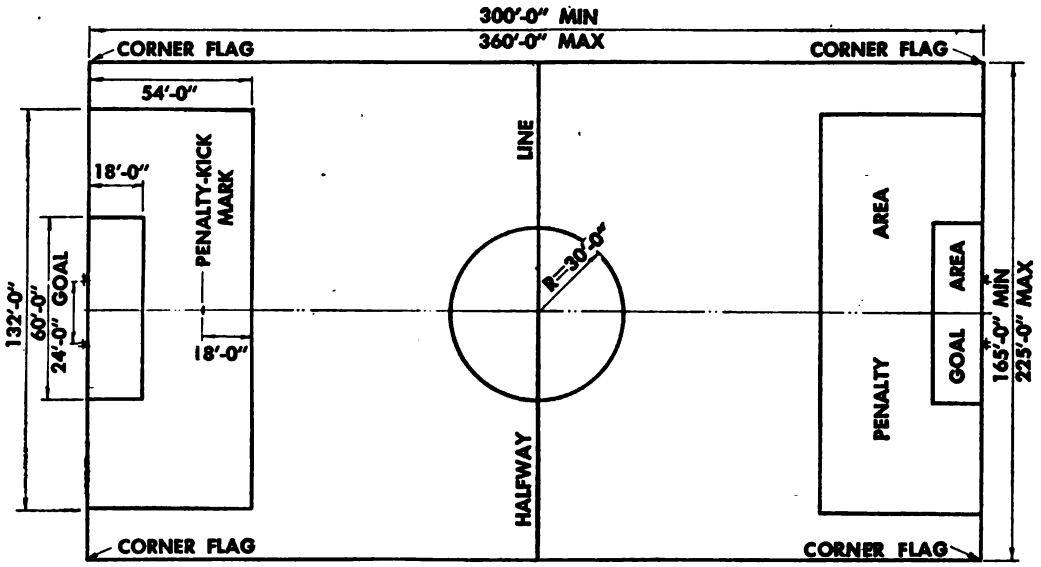


Figure 21. Soccer field.

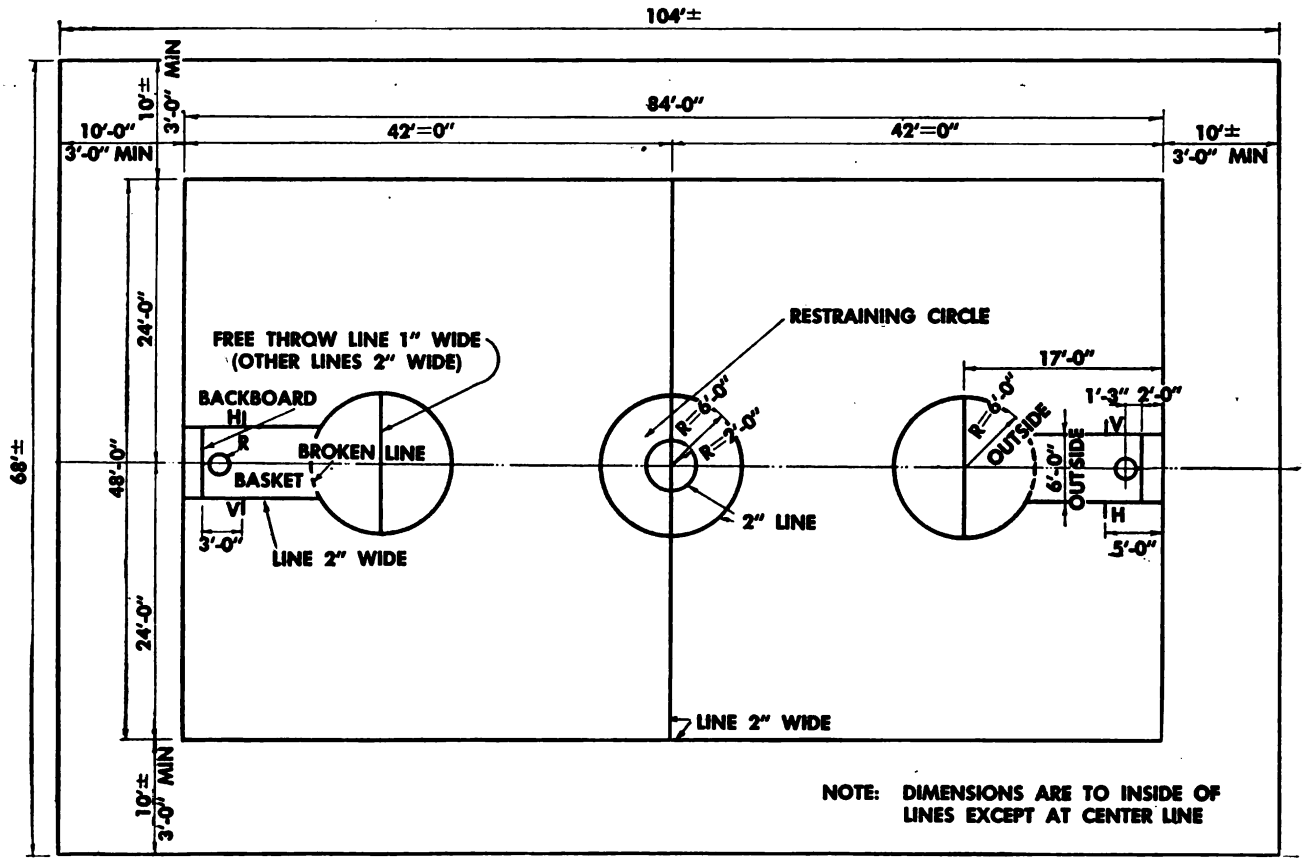


Figure 22. Basketball court.

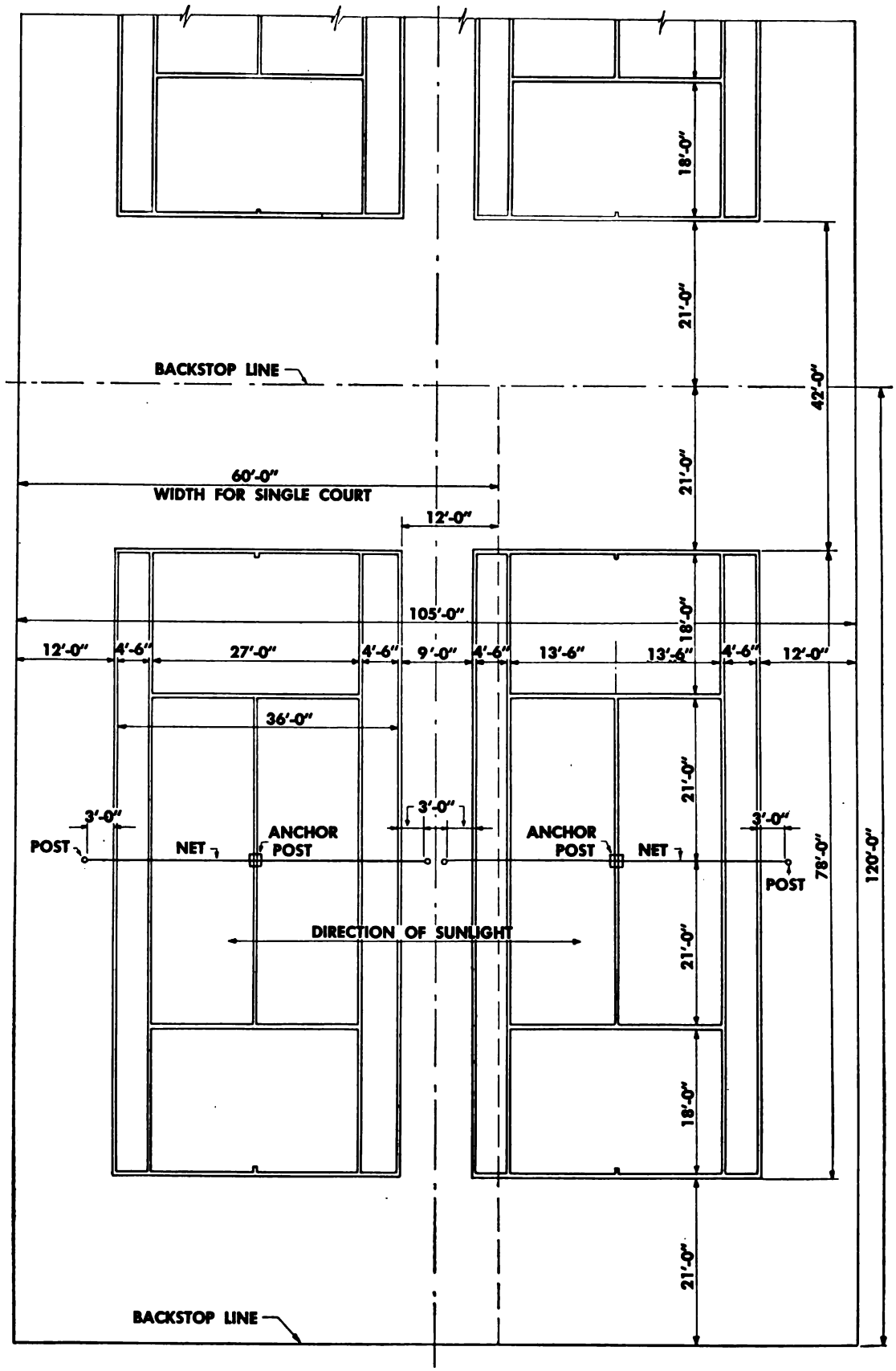
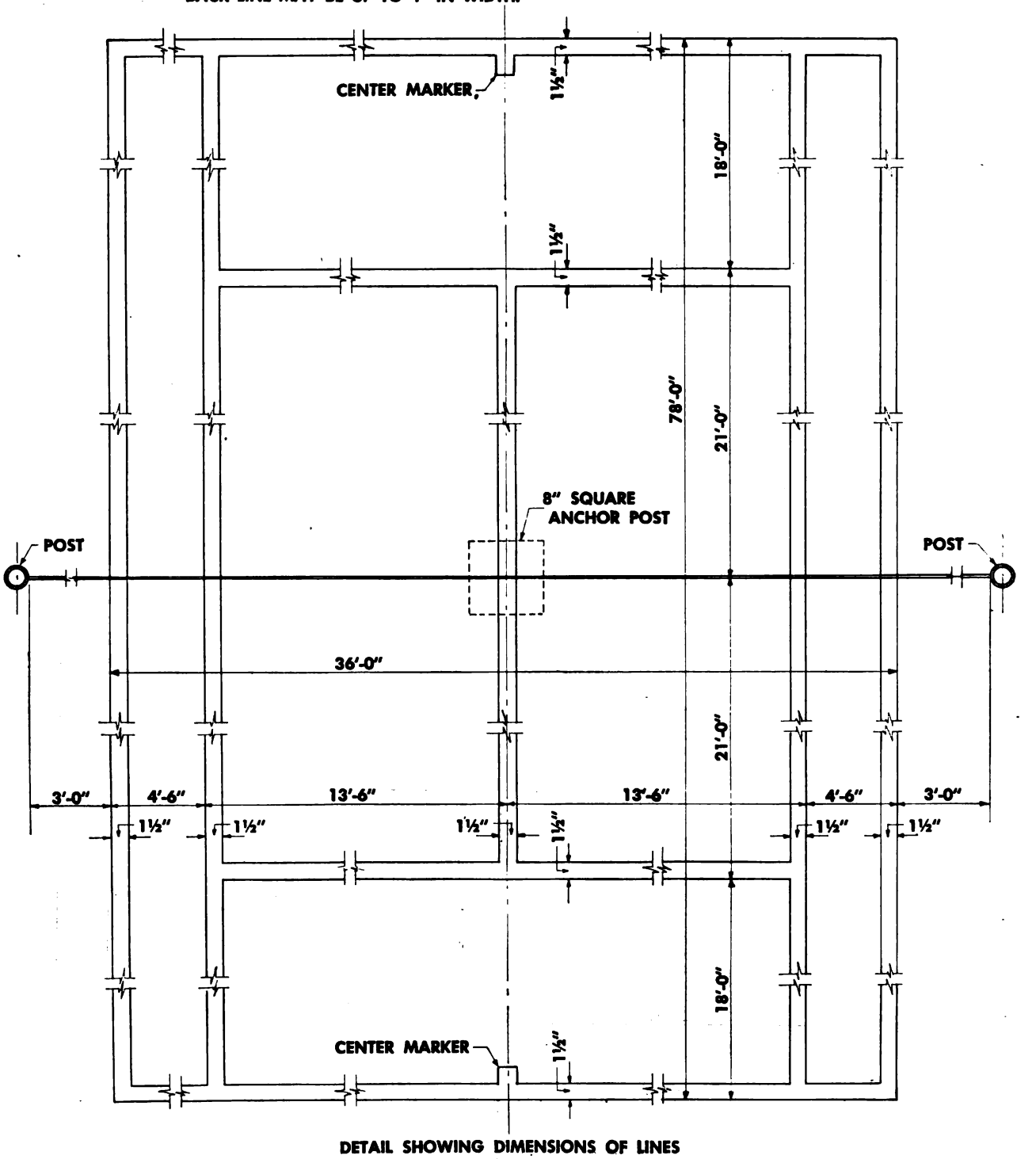


Figure 23. Lay-out for a battery of tennis courts.

NOTE: ALL LINES ARE 1½" WIDE.
DIMENSIONS FOR GROUND LINES ARE FROM OUTSIDE TO OUTSIDE EXCEPT FOR CENTER LINE WHICH IS TO THE CENTER OF COURT AS SHOWN BELOW.
BACK LINE MAY BE UP TO 4" IN WIDTH.



DETAIL SHOWING DIMENSIONS OF LINES

Figure 24. Plan for tennis court.

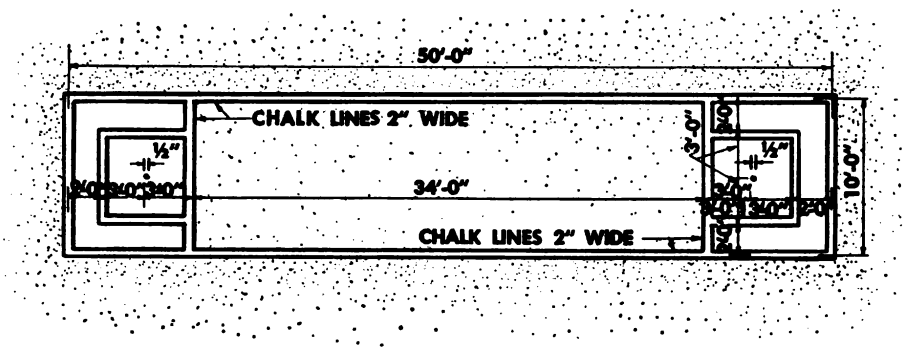


Figure 25. Horseshoe pitching court.

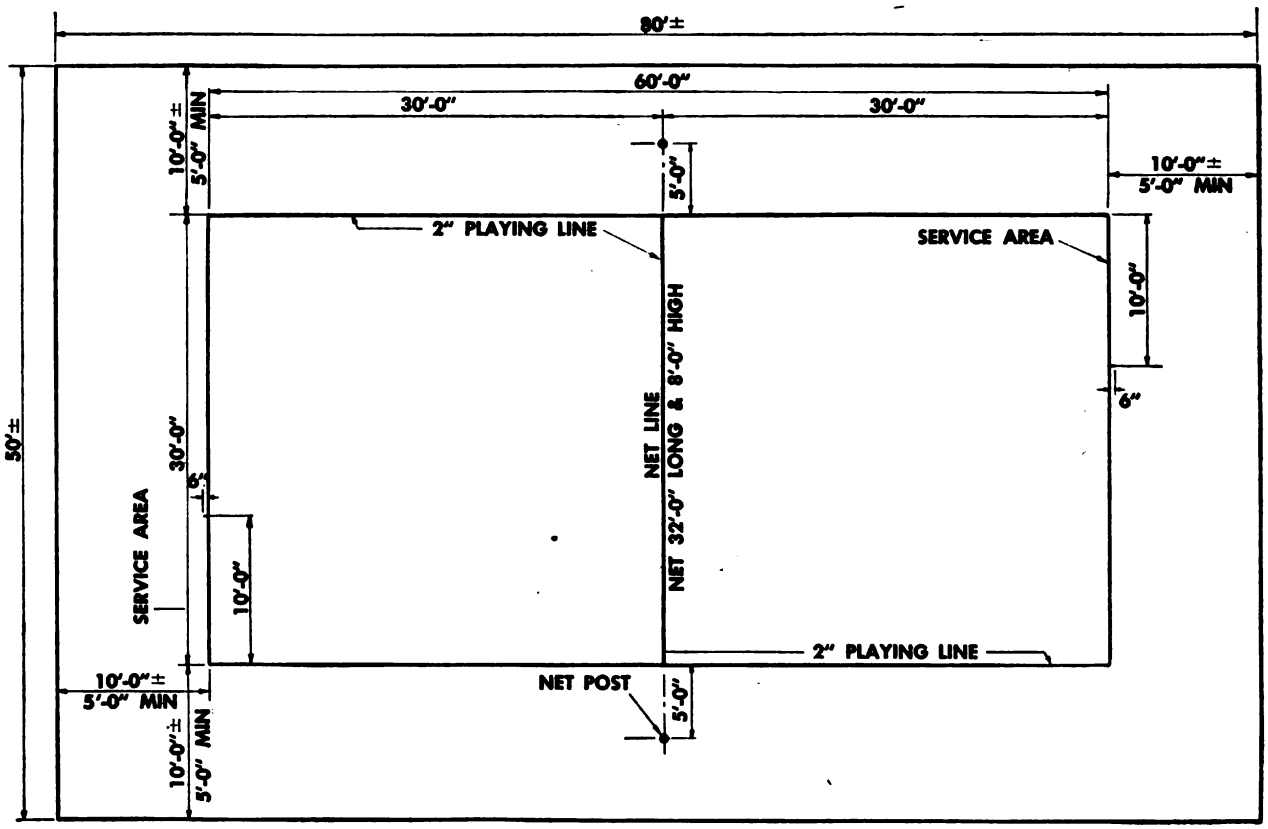


Figure 26. Volleyball court.

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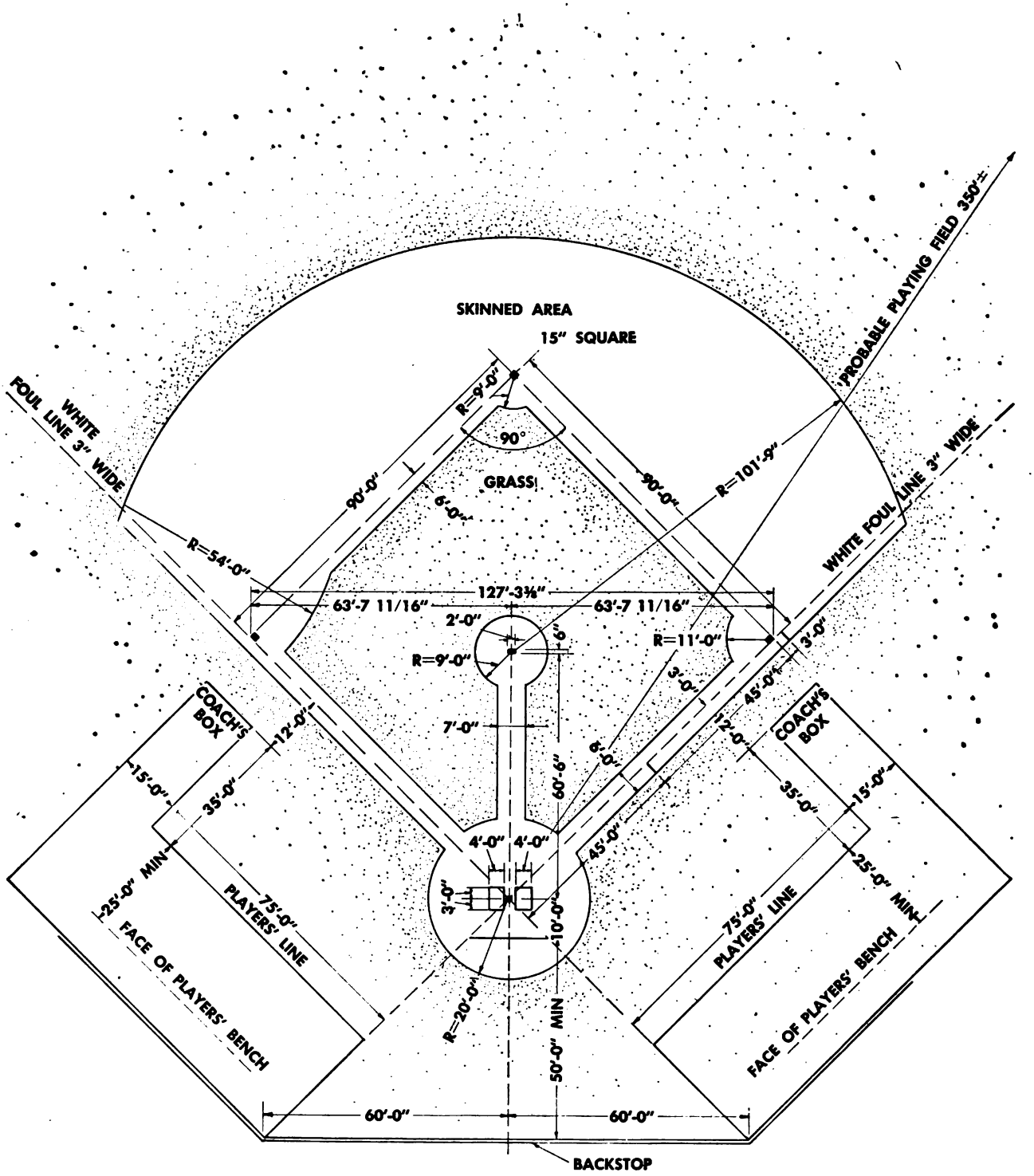


Figure 27. Lay-out for regulation baseball diamond.

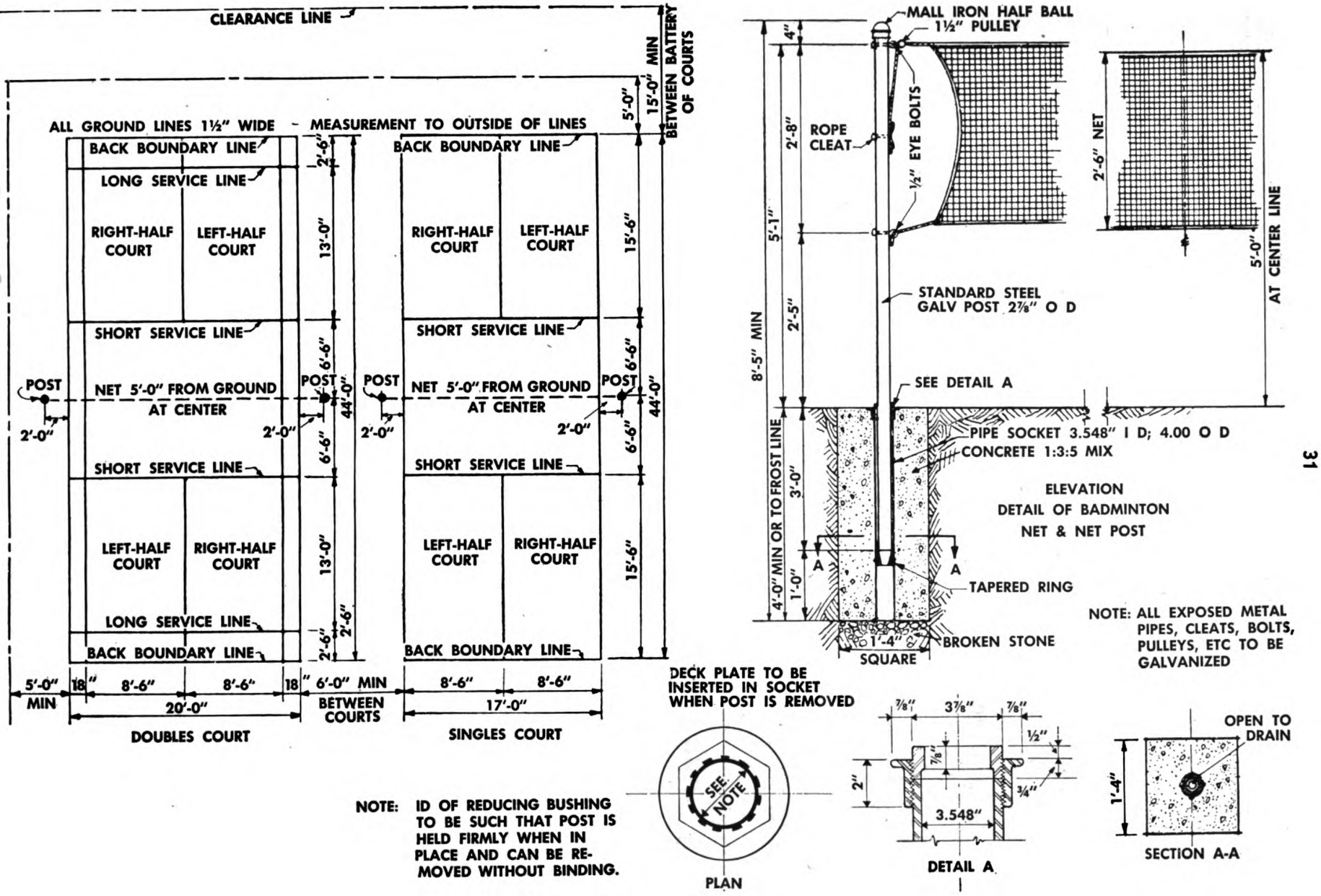
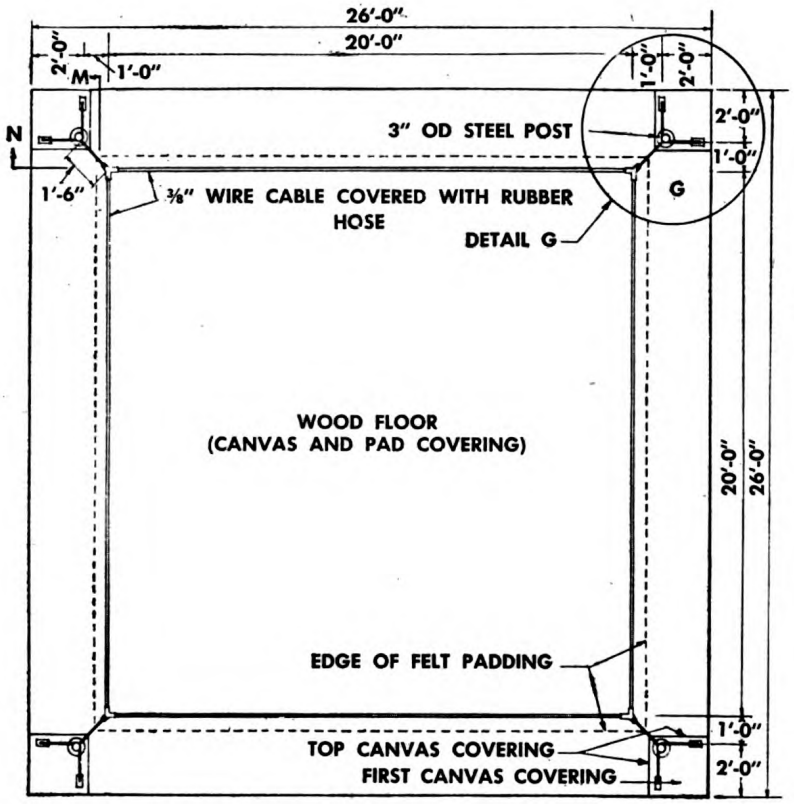
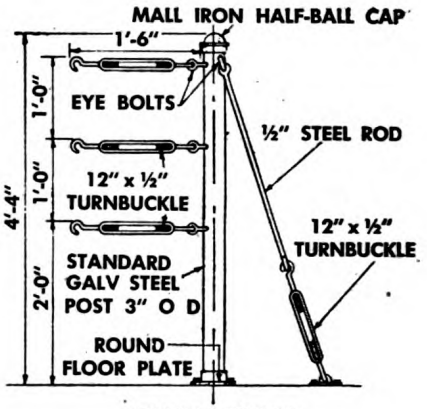


Figure 28. Plan for badminton court.



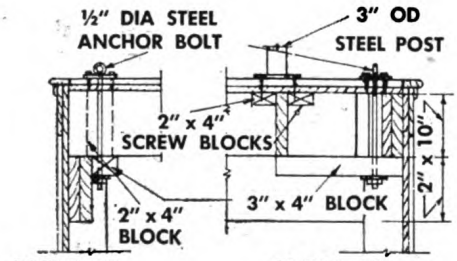
PLAN FOR BOXING RING



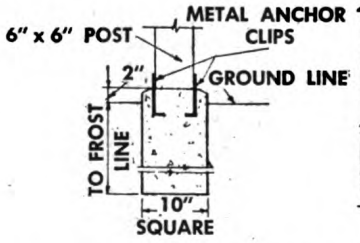
ELEVATION OF CORNER POST

NOTE:

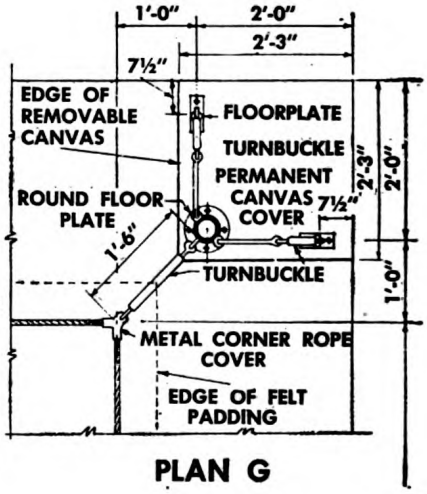
ALL EXPOSED METAL PARTS OF CORNER-POST CONSTRUCTION TO BE GALVANIZED



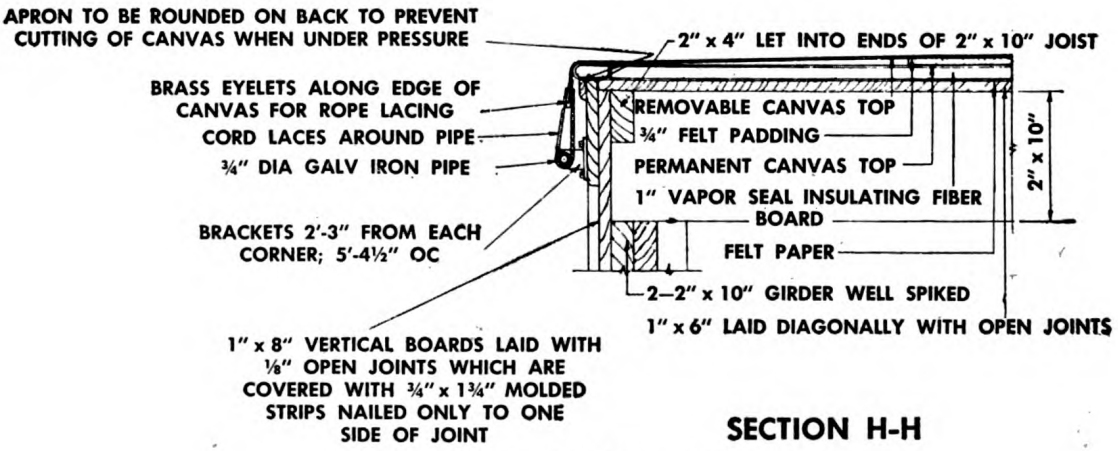
ELEV N ELEV M



TYPICAL FOOTING



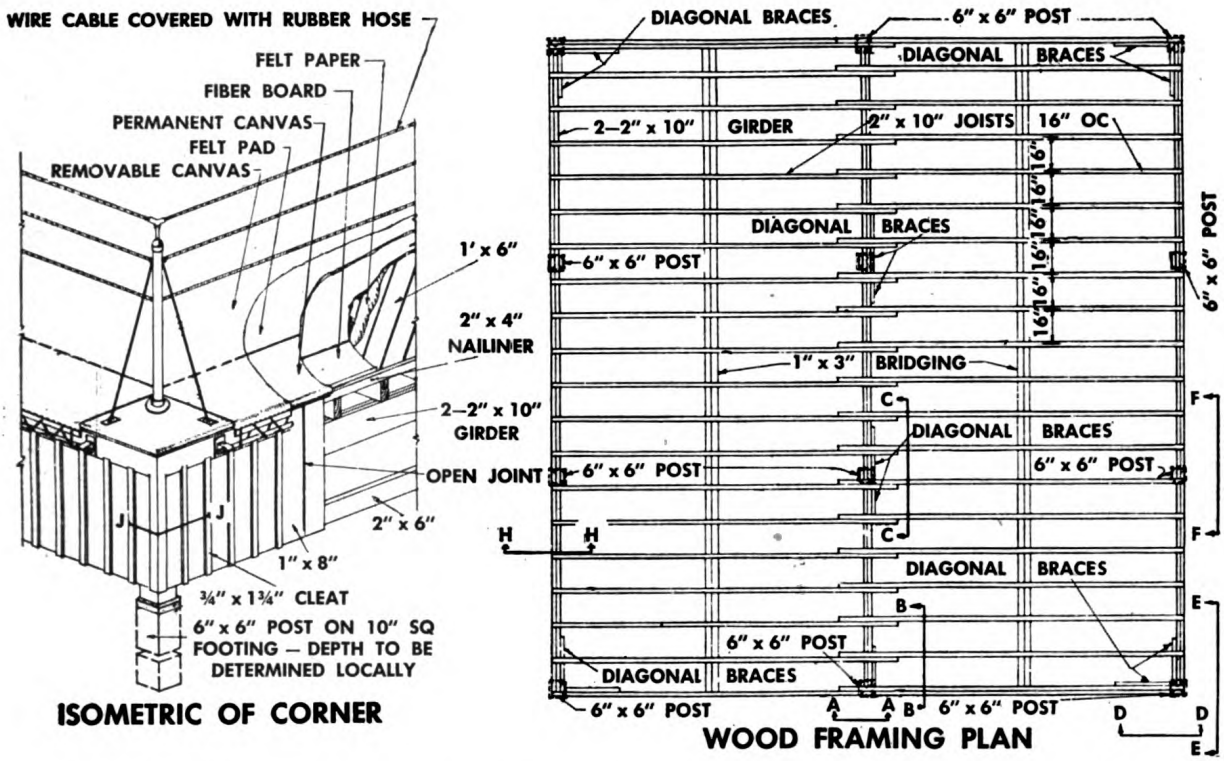
PLAN G

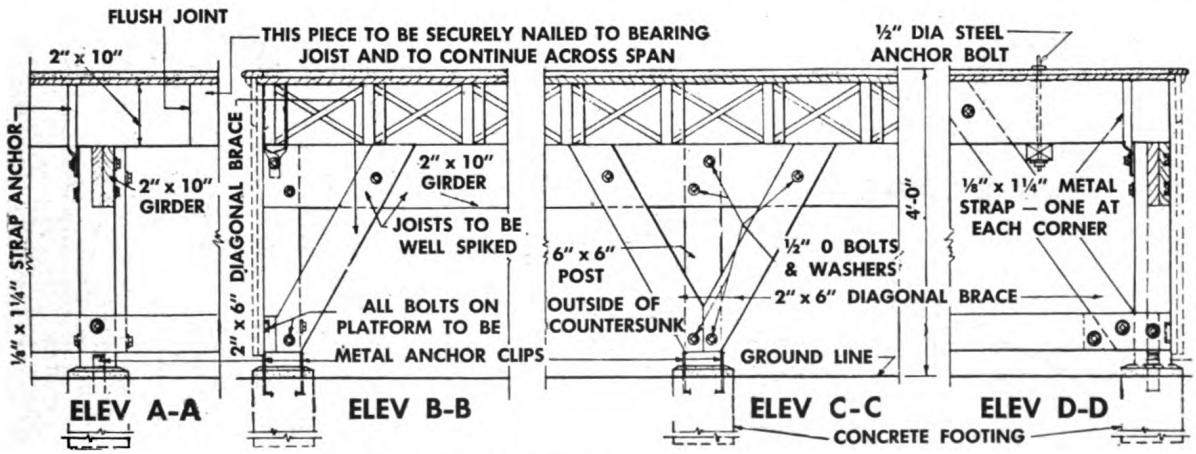


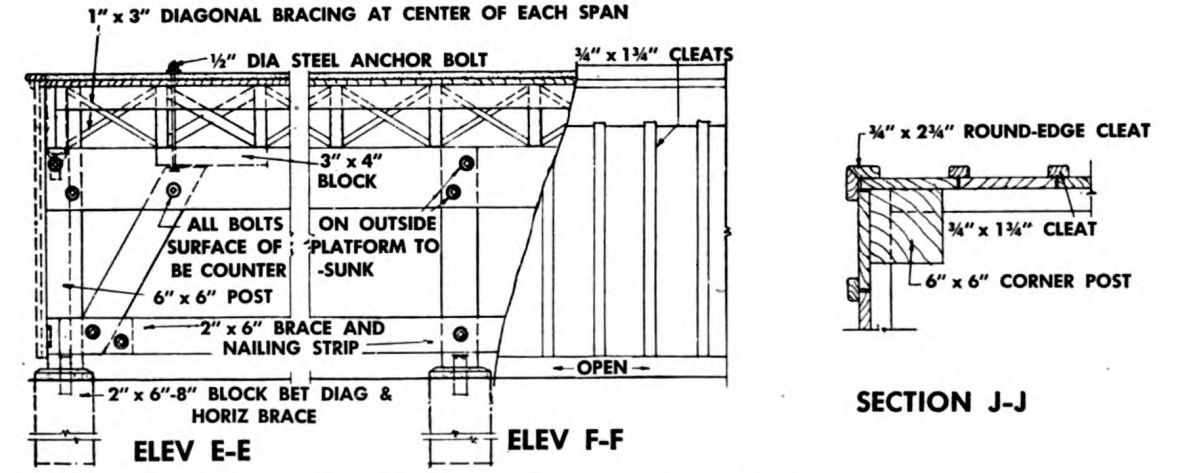
SECTION H-H

① *Lay-out diagram of boxing and wrestling ring.*

Figure 29

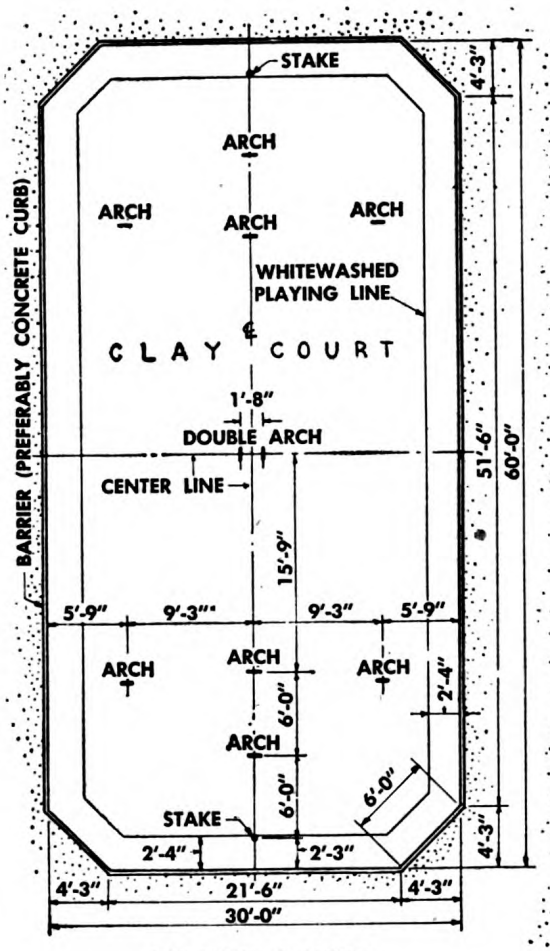




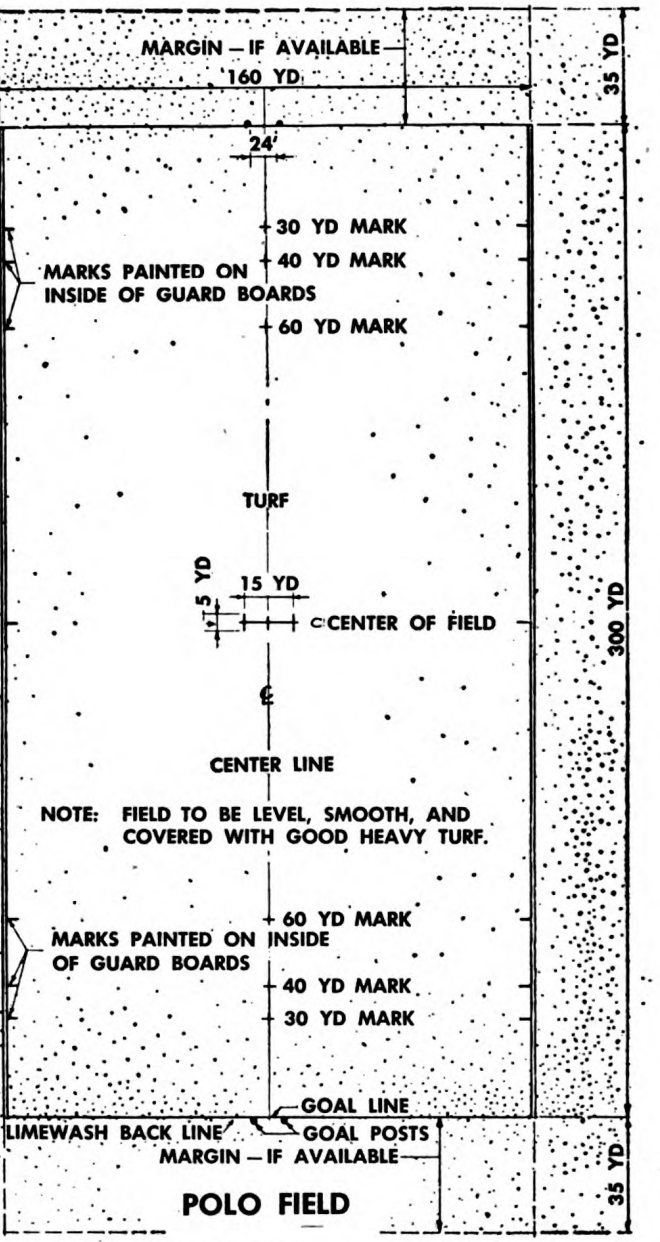


② *Construction details of boxing and wrestling ring.*

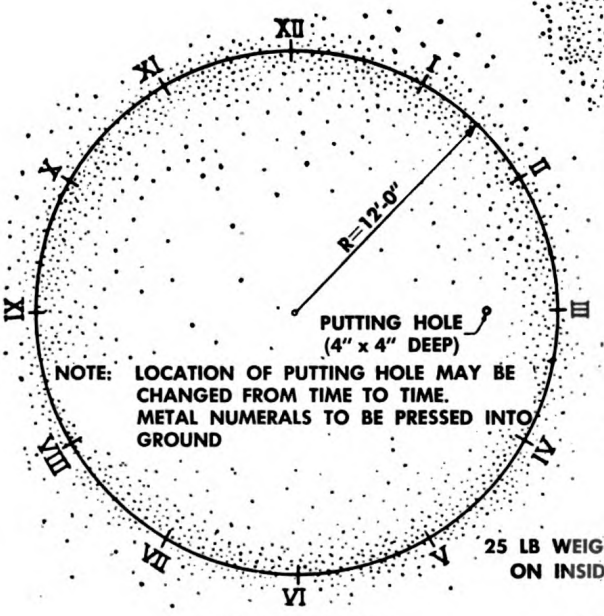
Figure 29.—Continued



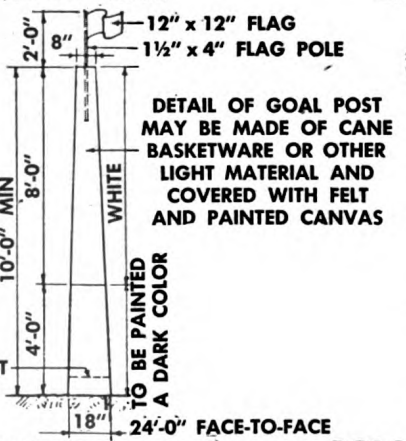
ROQUE COURT



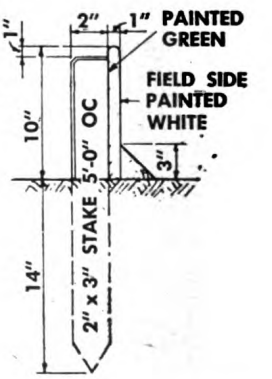
POLO FIELD



CLOCK GOLF



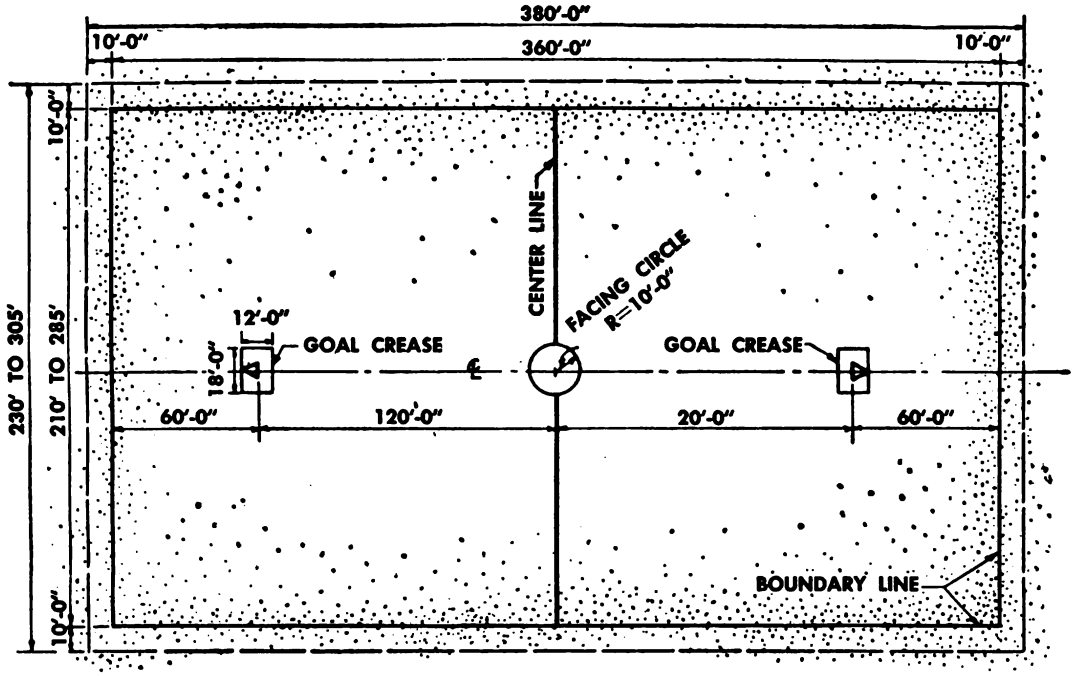
POLO GOAL POST



POLO GUARD BOARD

① *Lay-outs for miscellaneous sports.*

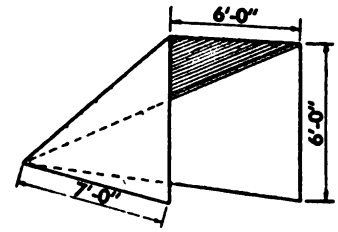
Figure 30.



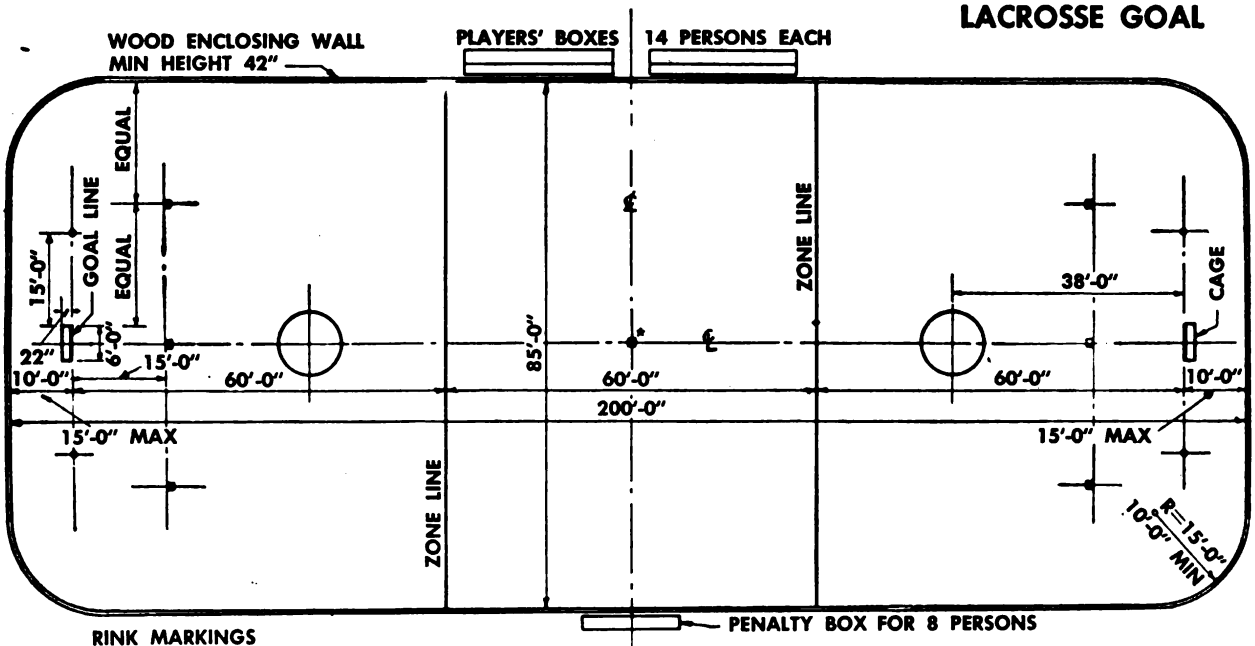
LACROSSE FIELD

NOTE:

BOUNDARIES OF LACROSSE FIELD ARE MARKED WITH WHITE LINES. AN EXTRA-HEAVY WHITE LINE DESIGNATES CENTER LINE. DIMENSIONS ARE TO INSIDE OF LINES EXCEPT AT CENTER LINE.
LACROSSE CAN BE PLAYED ON A FOOTBALL FIELD



LACROSSE GOAL



RINK MARKINGS

- □ 12" SQUARES (INSIDE) REQUIRED BY NCAA ONLY
- □* 12" CENTER SQUARE REQUIRED BY NCAA & AAU
- • SPOTS REQUIRED BY NCAA ONLY
- ○ 10' DIA CIRCLE REQUIRED BY NHL ONLY

ICE HOCKEY RINK

② *Lay-outs for miscellaneous sports.*

Figure 30.— Continued

14. Lawns

a. GENERAL. Lawns on military reservations usually require heavy-duty vegetation that is hardy, adapted to the locality, withstands traffic, and can be easily repaired or renovated. Use of grass meets the policy of Spartan simplicity when its primary function is to protect against dust and erosion and facilitate maintenance. Locally adapted grasses that are easily established and maintained are always recommended (see par. 5). Productive, loamy soils that retain moisture produce the best lawns; soils disturbed by construction and grading usually require more treatment and fertilization than the original top soil. Dried sewage sludge, compost, granulated peat, or other organic material mixed with the top 3 or 4 inches improve poor soils. Lawns should be sloped away from buildings to protect the structure and insure natural lawn drainage. The ideal seedbed is firm without air pockets, is free from weeds, contains enough surface moisture to insure germination, and has just enough loose surface material to cover the seed. Most lawn-grass seed is small and should not be covered more than ⅛ inch deep.

b. SOIL TESTS. The state experiment station can furnish valuable information on soils and make soil tests to determine acidity, alkalinity, and plant-food deficiency.

c. FERTILIZER. See paragraph 7.

d. LAWN MIXTURES. See paragraph 7. Usually a mixture of two or more adapted grasses of similar growth habits gives better results the first year than single species. Use domestic rye grass in mixtures to produce a quick cover because it is vigorous, grows rapidly, and quickly produces a pleasing appearance. However, rye grass does not last long and usually retards the permanent grasses if more than 5 or 10 pounds per acre are used.

e. RATE OF SEEDING. Use 2 or 3 pounds of seed per 1,000 square feet in most areas. When hand seeding small areas, use a little more seed to get uniform distribution.

f. TIME OF SEEDING. For proper time to sow seed, follow recommendations given in paragraphs 5 and 7.

g. VEGETATIVE PLANTING. For best results with such grasses as Bermuda, centipede, St. Augustine, and some bent grasses, establish a stand by sprig sodding or by planting stolons on a well-prepared seedbed.

h. SODDING. See paragraph 7.

i. ROLLING. Roll lawns with a hand-operated roller in early spring when soil is not too wet. Rolling firms the soil around the roots so they can grow to best advantage.

j. MOWING. Only pure bent-grass lawns, heavily fertilized and watered, thrive with close mowing. Mow at height of not less than 1½ inches. See paragraph 10.

k. WATERING. Water thoroughly each week during dry weather to maintain an attractive lawn. Light sprinkling plus close mowing ruins the lawn and stimulates crab grass and other weeds. Infrequent but thorough watering increases root growth and penetration; light sprinkling encourages shallow root development.

l. WEED CONTROL. If lawns are properly fertilized, mowed, and watered, weeds are not usually troublesome. Dandelions, chickweed, crab grass, and plantain are the most common lawn weeds, and they can be controlled by proper treatment. (See par. 11.)

m. INSECTS AND DISEASES. Obtain recommendations for control of insect pests and diseases from local authorities. A properly managed lawn does not usually suffer from disease. For additional information on insects attacking grassed areas, see TM 5–632 (when published).

n. RENOVATION. Abuse and mismanagement may necessitate renovation. To renovate a lawn, follow the procedure outlined for construction (par. 7). Many sick lawns can be repaired by top dressing ¼ to ½ inch deep with fertile topsoil or compost, reseeding, and complete fertilization. Supplemental treatment with 150 to 250 pounds of nitrate fertilizer per acre annually keeps lawns thrifty. Apply nitrate fertilizers when grass is dry to avoid injury from burning.

15. Traffic Control

The control of trespass traffic on nontraffic areas essential to proper maintenance, is of vital interest to the post engineer. Promiscuous and heavy traffic on grassed areas during their development or when the soil is wet must and can be prohibited on a well-disciplined post. Good quality grass, organic mulches, or other emergency dust-control measures cannot be maintained without restricting traffic to designated areas. Dust and erosion control as well as satisfactory maintenance vary directly with traffic control (see sec. IX, WD Cir. 211, 1944).

16. Removal of Debris

The last step in construction and the first step in maintenance is removal of all debris while the ground is still bare. All construction material, survey stakes, rock, cement, wire, broken machinery, fences, posts, lumber, and refuse piles that may interfere with training or maintenance equipment should be promptly removed. Policing must be continued, especially on airfields, to prevent rags, wire, metal, rocks, and debris from damaging mowing equipment. Thorough policing and good housekeeping are effective preventive maintenance procedures and save time and repairs. Operators of maintenance equipment should be instructed to police the area while at work, putting debris in a box attached to the unit

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Section III
EROSION CONTROL

17. General

Erosion by wind and water can be effectively controlled by proper vegetation, supplemented by mechanical structures where necessary. The success of any method depends upon properly adapting the control measure to the site. Before any treatment is begun, soil type, land slopes, and degree of erosion must be analyzed and a definite control plan formulated. Runway and road shoulders and areas adjacent to structures receiving concentrated water run-off require special attention.

18. Drainage

A complete water-disposal system is one of the first objectives in an erosion-control plan. This system must dispose of surplus water without disturbing the grade or slope of the land, protect natural or constructed drainage channels from scouring or silting, and prevent the undermining of buildings, roads, runways, parking areas, flumes, notch-spillway dams, culverts, and other structures.

a. Draining Low Areas. (1) *Gravity ditches.*

(*a*) Use unprotected channels if they can be designed practically to operate at nonerosive velocity.

(*b*) Protect ditches with vegetation, either by seeding or sodding, where they can be designed to operate at a velocity not exceeding 8 feet per second. Grasses for this purpose can be suggested by the service command agronomist, county agricultural agent, U. S. Department of Agriculture technician, or state experiment station official. To establish grass from seed, heavy applications of fertilizers, mulching, tying down mulch, and watering are often necessary.

(*c*) Protect ditches with concrete, rock-masonry, or metal-pipe structures when one or more of the following conditions are met:

1. Where periods of continuous flow exceed submergence tolerance of the grass.
2. Where sod flumes cannot take care of large overfalls, especially where the lower part of the flume is submerged long enough to kill the sod.
3. Where waste oil or other matter injurious to grass is carried in the channel.
4. Where irrigation is not practical and vegetation cannot survive without it.

Note. Drainage channels should be designed to carry the maximum run-off shown by a 10-year experience table. Where great damage may result from failure, the design should be based on 50- or 100-year experience. For run-off calculations, see U. S. Department of Agriculture Miscellaneous Publication No. 204, Rainfall Intensity—Frequency Data, by D. L. Yarnell. (See also TM 5–624 (when published).)

(2) *Pumping.* When the topography of area prevents use of any system of gravity ditches to drain low areas, drainage by pumping may be necessary.

b. Draining Sloped Areas. Some precautions should be taken in sloped areas to prevent rapid run-offs from causing rills and gullies:

(1) Sod-forming grasses should be established.

(2) Properly designed and constructed system of vegetated terraces should be set up.

19. Gully Control

Methods of gully control depend on the use of the area and the gully's effect on adjacent areas used for buildings, recreational, or training facilities (figs. 31 and 32).

a. Where only stabilization of the gully is required, follow applicable procedures given below:

(1) Plant trees, shrubs, or grass where native vegetation is sparse or does not reestablish readily (figs. 33 and 34).

(2) Mulch with straw, brush, or other material when necessary to protect seedings.

(3) Use temporary dams of brush, bags of earth, logs, woven wire, and other materials when needed to enable vegetation to get a start.

(4) Slope vertical banks to facilitate growth of vegetation.

(5) Divert water away from gully heads by ditches or dykes if caving is a factor.

b. If the land is to be used, filling or sloping gullies may be necessary. Before such work is begun, plans to remove the cause of the gully or divert the water must be made to prevent recurrence. To slope the gully banks, essential for

slope steeper than 2½ or 3 to 1, follow the procedures given below:

(1) Use a bulldozer for most effective results in grading, or terracer can be used if necessary (figs. 35 and 36).

(2) Establish vegetation as desired, using a thin mulch of straw or other material.

(3) If the water has not been diverted completely, maintain the channel by sodding if necessary to prevent soil washing.

(4) Check the need for temporary or permanent diversion of water by dykes, ditches, or channels. Make required installations before leveling.

20. Roadside Erosion Control

The value of roadside erosion control in reducing maintenance cost has been demonstrated by many state highway departments, cooperating with the Bureau of Public Roads and the Soil Conservation Service. The procedures shown below also apply to target butts and other embankments. Proper cross sectioning of ditches and roadsides is considered the most important erosion-control factor.

a. Mechanical Methods. Mechanical methods of erosion control can be greatly minimized by proper highway design. Qualified personnel who appreciate the need for erosion control are needed in highway work. State or local highway authorities can assist with highway erosion problems. U. S. Department of Agriculture engineers can also advise and assist with planes for erosion control.

(1) Little special equipment is needed for erosion-control work other than regular highway equipment, except that listed in paragraph 7 for sodding and seeding.

(2) Various structures to facilitate erosion control along highways include berm ditches, paved ditches for unavoidably steep slopes, and drop inlets.

Figure 31. Open gully caused by concentration of water from adjoining land.

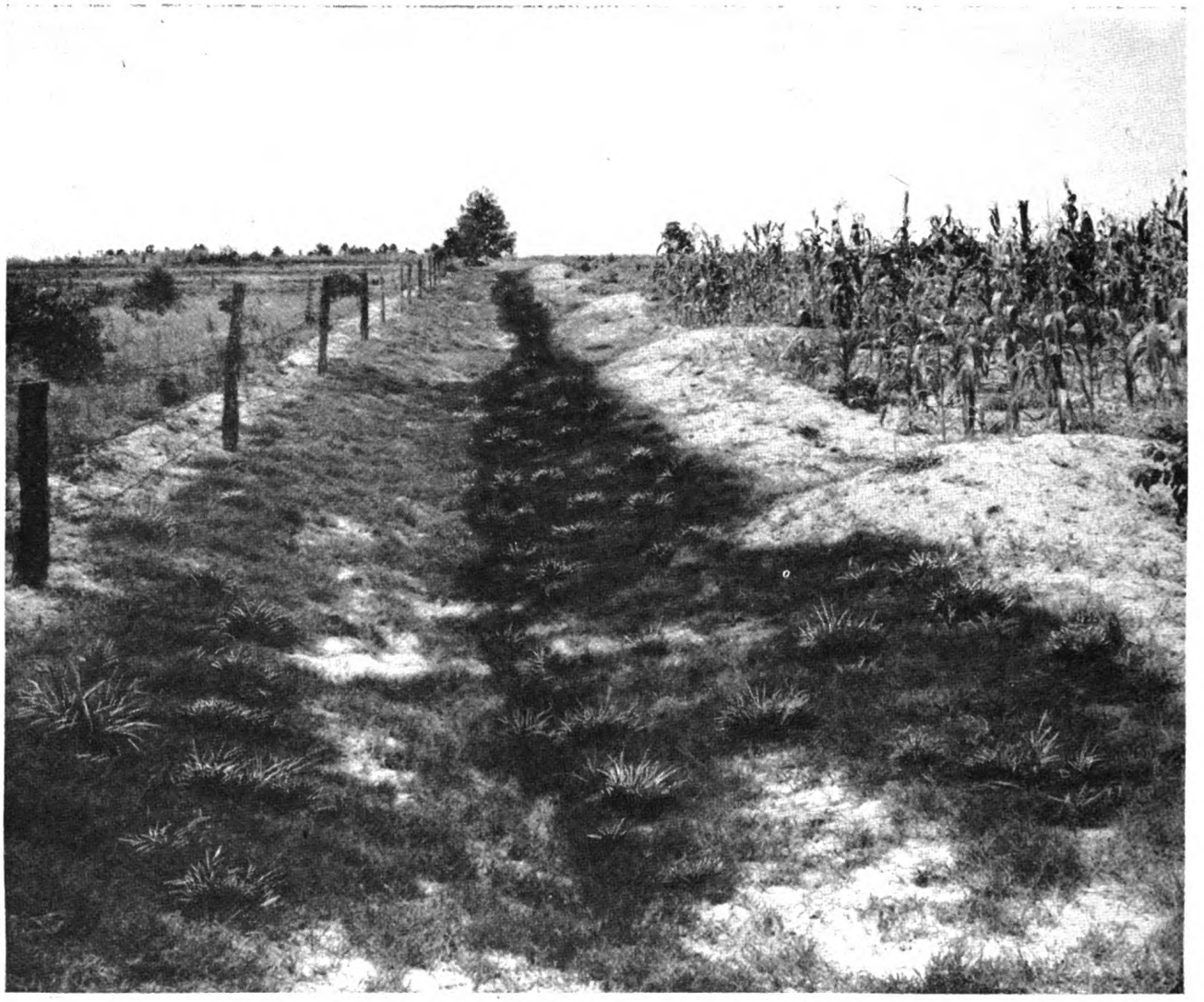

Figure 32. Same gully as shown in figure 31 after ditch banks were flattened and Bermuda grass established. Water can now be carried without danger of erosion.

(3) In planning grading operations to prevent erosion, the original cost as well as subsequent maintenance costs must be considered.

(4) Although some soils erode more easily than others, embankment slopes and highway cuts must not exceed 2 or 3 to 1 if they are to be vegetated by ordinary seeding methods. Where slopes cannot be reduced to this extent, sodding is necessary. Information on soil stability is essential before degree of any slope is determined. Consult local soil authorities.

b. VEGETATION. (1) Adapted vegetation is essential for roadside erosion control. Methods of soil preparation, seeding, sodding, and fertilization described in paragraphs 7 and 9 can be followed to obtain a firm sod. Broadcast sodding (par. 7) with rootstalk grasses like Bermuda and Kikuyu are especially effective and economical.

(2) In addition to the usual light-mulch method for covering new seedings, mulching with 1 ton per acre of native hay harvested after seed is formed is also effective. If the hay is packed down with a cultipacker, the seed in the hay soon establishes a grass cover. Where bare soil needs protection for several months when seeding is not feasible, a heavy 2-inch mulch of straw, hay, or other material is desirable. This method can be used for sand dunes and other areas where vegetation is difficult to establish.

Figure 33. Land of this type cannot produce sod without first being renovated.

Figure 34. Same scene as figure 33 shown 3 years later. Phosphate and manure were applied. Kudzu plants were set out

Figure 35. Deep gully receiving treatment. Sides are sloped with a bulldozer.

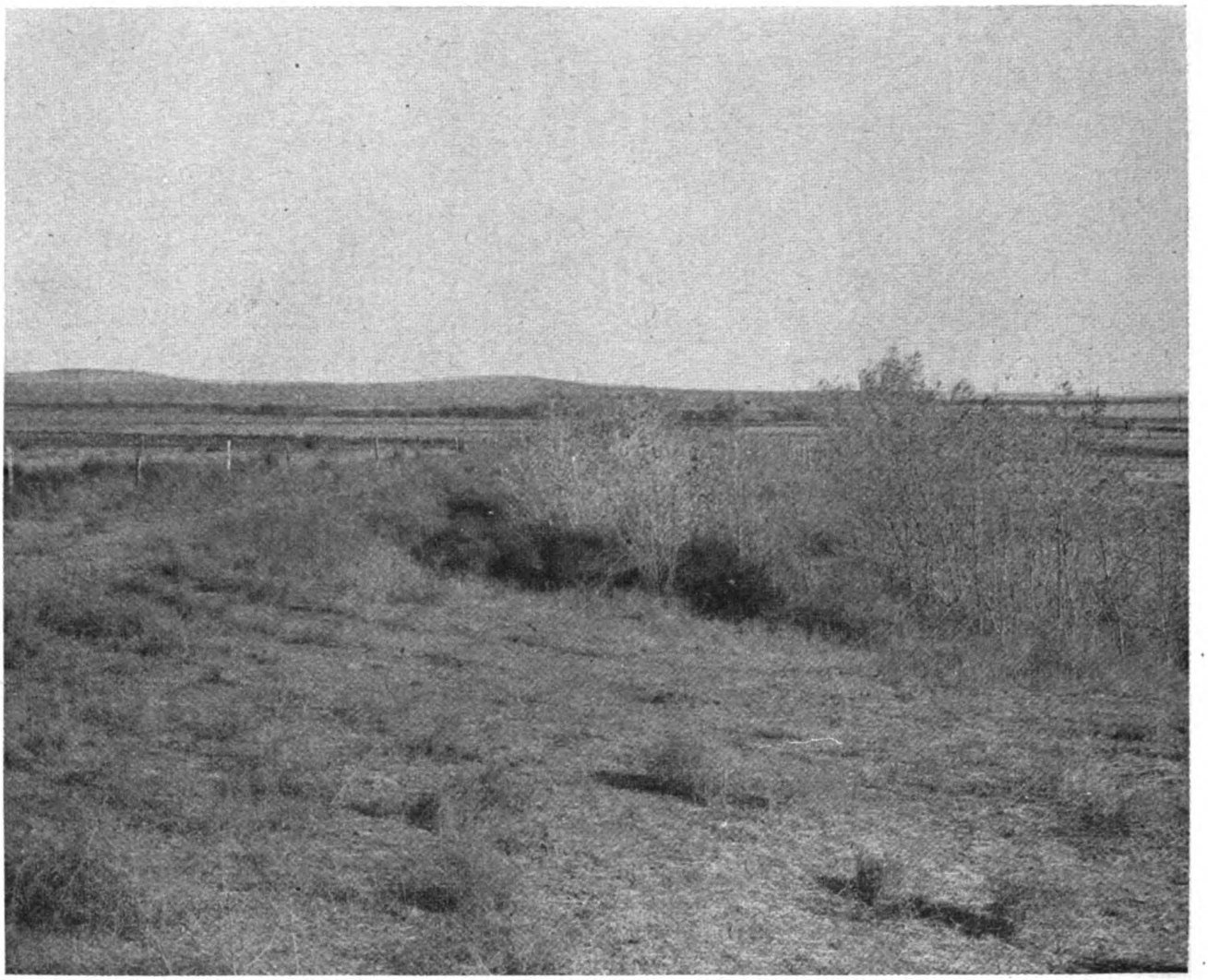

Figure 36. Same scene as figure 35 after 3 years. Stabilized outlet controlled by vegetation.

Section IV
DUST CONTROL

21. General

Dust control is especially necessary in areas where high-cost, delicate equipment is operated or where personnel are concentrated for training. Airfields, hangars, shops, hospitals, drill fields, athletic areas, parking lots, and storage yards are all subject to inconvenience and damage by dust (fig. 37). Although methods of control vary with the soil, climate, and land use, adapted perennial grass should be considered first because it is the most economical method. In some areas, annuals can be substituted for permanent grass although they are not as satisfactory (par. 5). Where vegetation cannot be maintained, other dust-control measures can be used. The material selected should be readily available and not impair the area for its intended use. Such materials include the following:

a. Organic mulches of hay, straw, sorghum stover, and the like.

b. Light-grade dust-palliative oils and MC–1 (fig. 38).

Figure 37. Dust from bare, smooth ground reduces visibility and is harmful to both man and machines.

Figure 38. Runway shoulders oiled to prevent dust.

c. For temporary control, a 2-inch blanket of gravel and cinders (see TM 5–624 (when published)) or rough tillage.

d. Calcium chloride has been used but has not usually been effective because of dryness of the air and the caustic and corrosive effects of the chemical.

22. Mulching

Organic mulch of low-grade grass, hay, straw, coarse manure, sorghum stover, or similar material is generally used at the rate of 1 to 2½ tons per acre dry weight. This prevents dust from blowing and also controls water erosion by increasing absorption or infiltration. It provides partial shade which reduces the rate of evaporation and protects young, seedling grass plants. The organic material improves soil productiveness by adding humus and increasing bacterial development. Although organic mulches are usually temporary measures, they substitute for growing vegetation in low-rainfall areas if replaced about every 2 years. It is not a satisfactory substitute on athletic areas, drill fields, and parade grounds, and only partially successful on runway, taxiway, or apron shoulders receiving prolonged propeller blasts.

a. Apply mulch either by hand or by spreading machines (fig. 39) any time of year the soil is in good workable condition. Distribute it uniformly at the proper rate. For dust control, use as much as 3 tons per acre if necessary. After seeding, use a much lighter application, usually 1 or 1½ tons per acre, permitting the soil to be visible and spreading all bunches or piles uniformly.

b. Anchor the mulch on open areas subjected to high wind. Loosen the soil about 5 inches deep (fig. 40), apply mulch, and press it into the soil with a large disk set straight and weighted down. In lieu of a disk, use the Campbell packer, the sheepsfoot roller, or the Dunham rotary hoe run in reverse (fig. 41). Additional packing or watering is unnecessary. If the mulch material is dry and brittle, wet it before applying. After the mulch is applied, the area should look like a stubble field (fig. 42). To seed mulched areas, drill seed without disturbing the mulch more than necessary.

c. The cost of mulching depends on availability and cost of material, rate of application, and labor, but it should not exceed $50 or $60 per acre.

Figure 39. Mulch material spread with home-made machine.

Figure 40. One method of preparing soil for mulch.

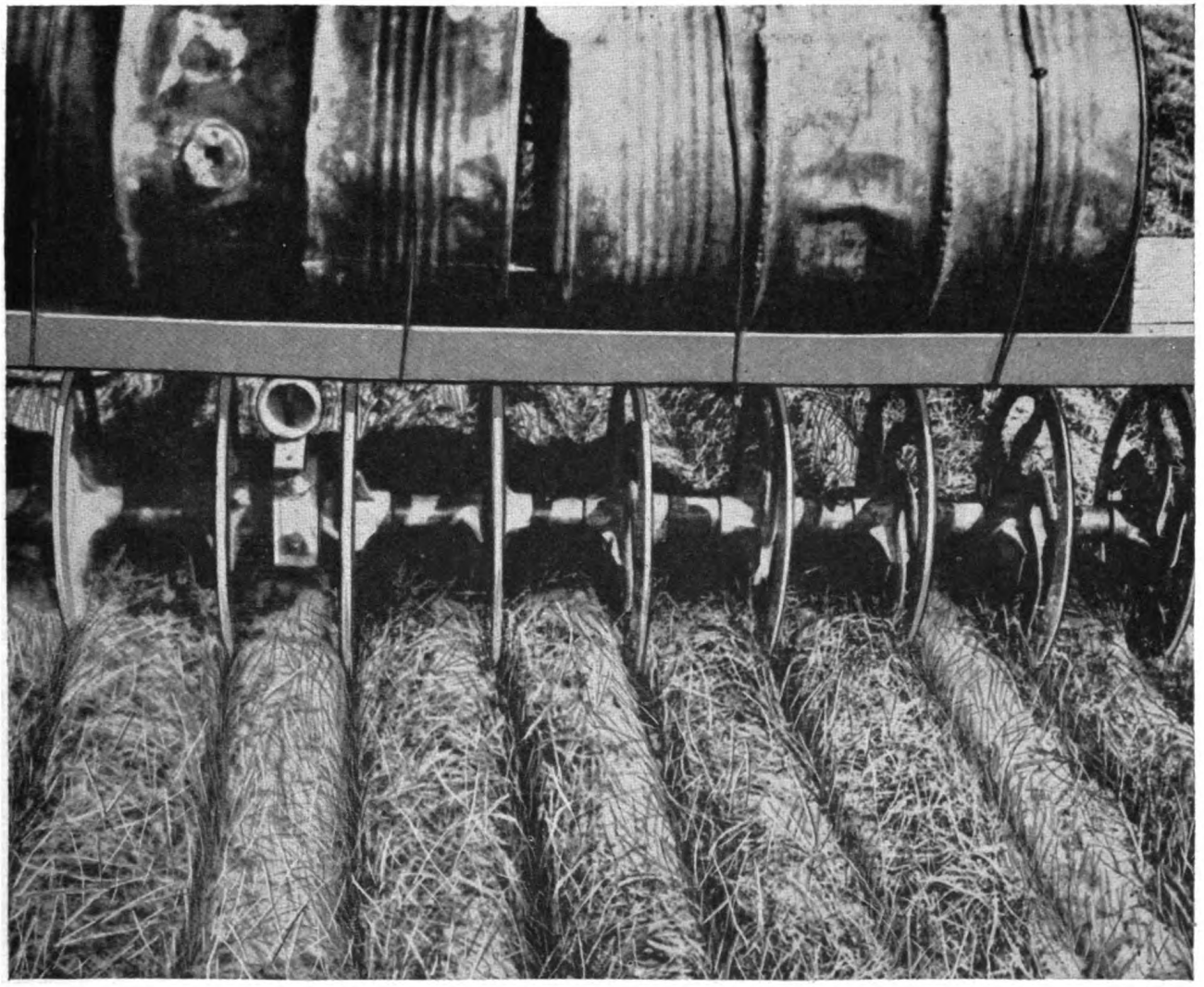

Figure 41. Anchoring mulch by pressing it into the loose soil.

Figure 42. This is how a well-mulched area should appear.

23. Oiling

Dust-palliative oils of various kinds to control dust on limited areas are fairly successful when applied two to four times per year. Oils work best on athletic areas, drill fields, parade grounds, and work areas subjected to foot traffic, but they do not support heavy traffic. Several light, non-staining, dust-palliative oils are being developed, but those now available are very short lived. The heavier MC-1 (medium-grade road oil) is more durable but is dark in color and stains clothing and floors. Oils are less objectionable than calcium chloride and can be applied quickly and easily.

a. In applying dust-palliative oils, follow the manufacturer's instructions. Apply oils to moist soil scarified lightly from 1 to 2 inches deep and rolled or dragged level. Pulverize the surface, watering as shown in figure 43 with 1 to 1½ gallons per square yard if the soil is dry. Apply oil at rate depending on grade of oil and type of soil. The light oils are usually applied at the rate of 0.3 gallon per square yard and MC–1 about 0.4 gallon per square yard. The total cost of each application should not exceed $300 per acre.

Figure 43. Watering immediately before application of oil.

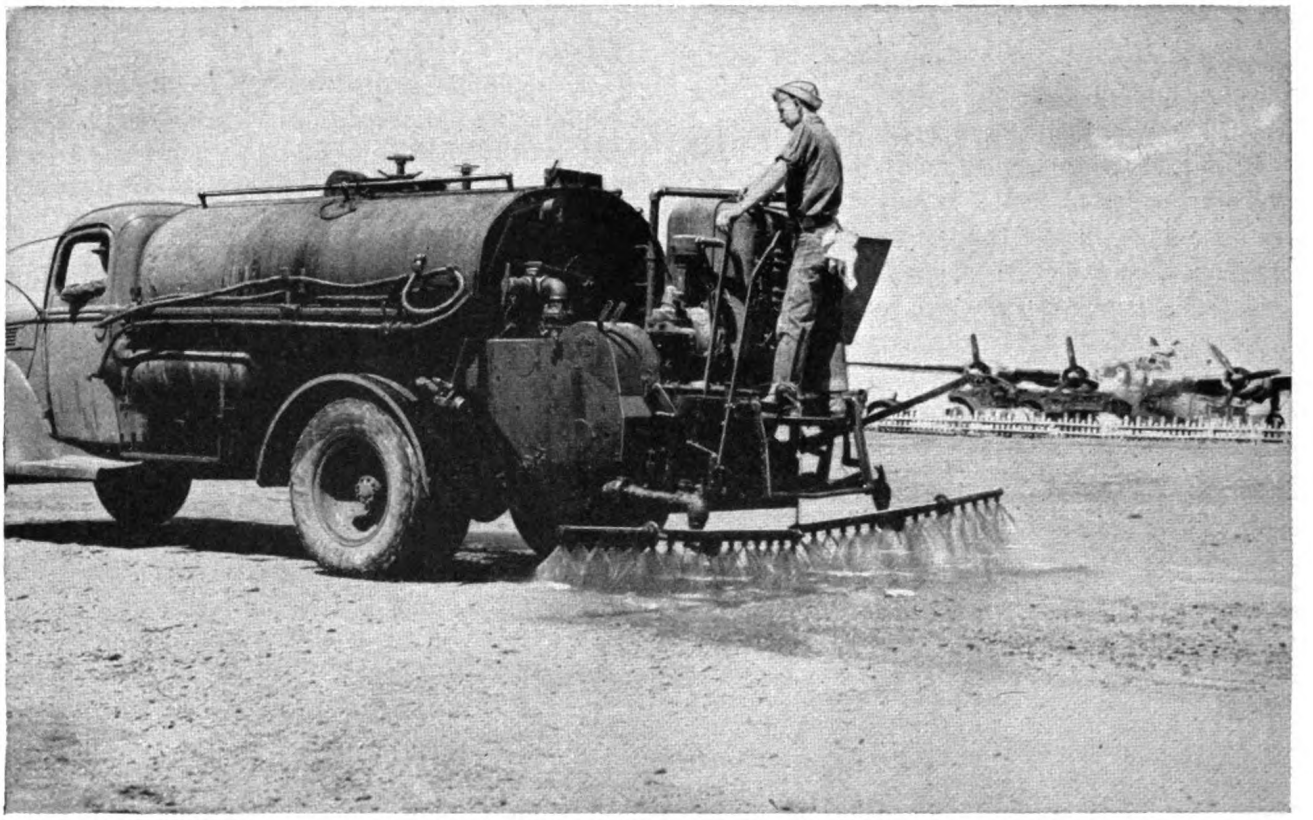

Figure 44. Applying oil with distributor.

24. Seeding and Sodding

The control of dust by vegetation is generally preferable to any other method. Transplanted roots and rootstocks of Bermuda grass and several other species are sometimes substituted for both seeding and sodding or used with seeding. Seeding is always the most economical but requires more time; sodding gives immediate results but the high cost limits its use to such areas as small drainage ways, steep banks, outlet channels, areas around catch basins, critical lawn areas, and other locations requiring immediate protection.

a. For dust control, quick-growing cover crops such as Sudan grass, rye or other small grain, rye grass, and millet should be used. If such crops are mowed before maturity, they provide a stubble for dust control the following season. Temporary crops can be continued or used in establishing perennial grasses when the grass seed is drilled in without disturbing the stubble cover.

b. General procedures for sodding are given in paragraph 7. Strip sodding, placing strips at intervals across slopes, is not satisfactory because erosion usually occurs between the strips if bare areas are not seeded and mulched. Spot sodding, planting pieces at intervals so new growth eventually covers the entire area is fairly successful. Spreading grasses like Bermuda and buffalo are best for this purpose.

25. Gravel and Cinders

Crushed rock, gravel, and cinders may be applied on unused areas adjacent to mess halls, theaters, technical areas of airfields, and similar locations. The material should be spread 2 inches thick over the area treated. Gravel or crushed stone 1 to 2 inches in size are effective; river gravel may also be used if available. The initial cost of this type of dust control is usually high, depending on hauling distances, but maintenance cost is low. It is used at permanent installations where other methods cannot be employed (fig. 45).

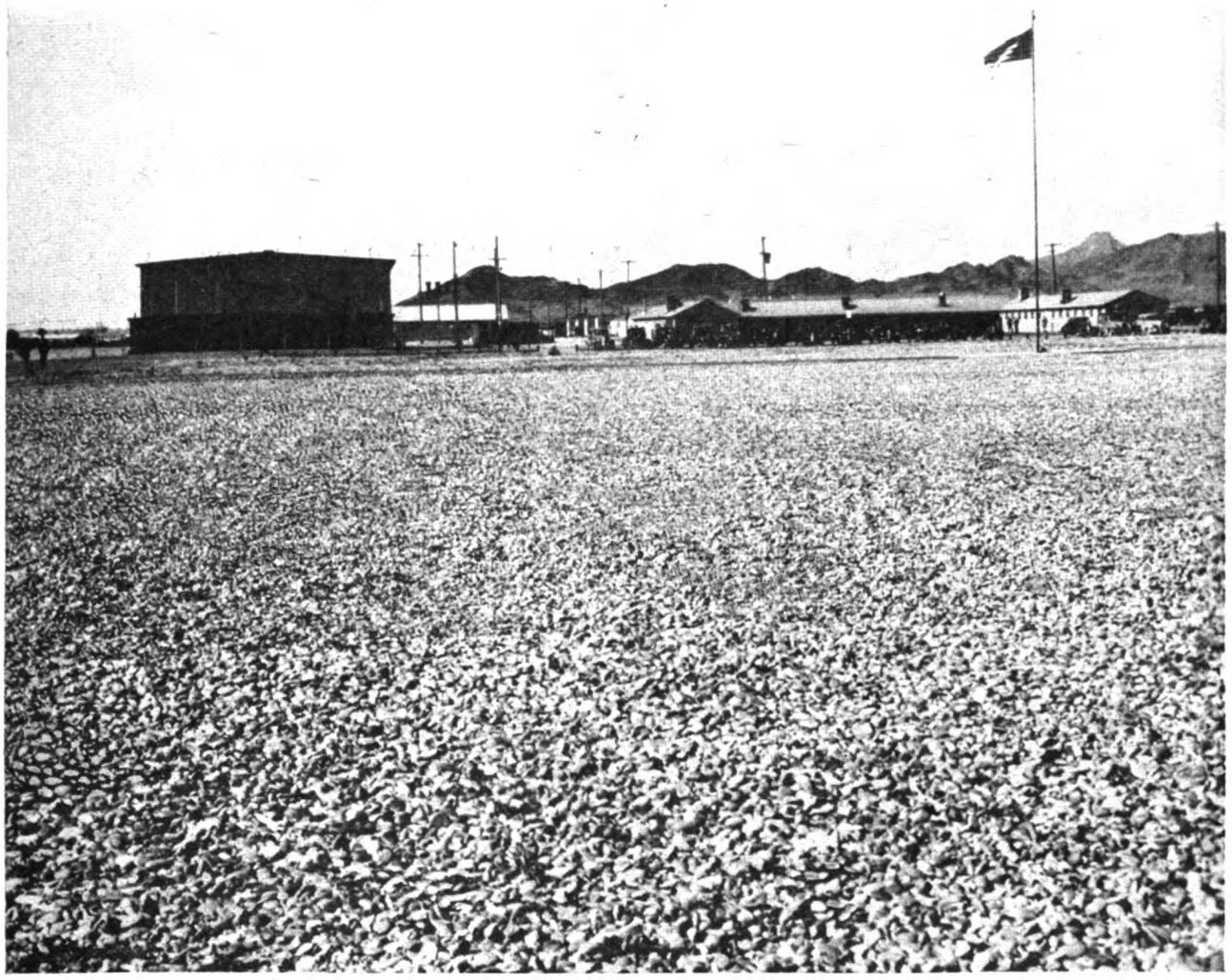

Figure 45. Gravel blanket, another treatment for dust control.

26. Temporary Control Measures

When accidents, intensive use, or extreme weather conditions cause failure of existing dust control, temporary measures must be employed.

a. Rough tillage is usually the first step, consisting of scarifying or chiseling the soil to create a cloddy or rough surface (fig. 46). Rough tillage is effective on all heavy soil that breaks up in stable clods but ineffective on loose sandy soils. Satisfactory control can usually be obtained by scarifying alternate strips leaving 50 to 80 percent of the soil undisturbed. This work should start on the upwind side of the field and be done at right angles to the wind direction. Two or three operations may be required during the windy season.

b. Coarse mulch around parking aprons, or other areas subjected to prolonged propeller blasts, held in place by some heavy mat such as reinforcing steel, woven wire fence or light rod-and-bar mat, is another temporary measure. Vegetation should be established to replace temporary measures as soon as possible.

Figure 46. Temporary dust control by rough tillage.

Section V.

STREAMS AND OPEN DRAINAGE CHANNELS

27. Removal of Obstructions

In streams where flow is normally sluggish but rapid at times of high water, the channel must be cleared periodically of brush, logs, silt, and debris which pile up around small obstructions, causing bank washing, flooding, damage to structures, or destructive ice jams. Channels near bridges and other structures must be carefully maintained to prevent undermining of footings or washing behind abutments and other protective units.

28. Check Dams

Where a naturally steep gradient causes a rapid flow in small streams, a series of check dams can be built to prevent stream-bed erosion. These dams form sections or steps of safe gradient between each structure or dam. A natural bed of rock, gravel, or boulders normally does not need such protection.

a. MATERIALS. Temporary check dams are built of fencing and brush, loose rock enveloped by woven wire, or untreated timber or logs. Permanent structures are built of treated timber, stone masonry, or concrete.

b. DESIGN. Important features in check-dam design include the following:

(1) Notches large enough to discharge flood waters without allowing the banks to be washed out at the edges of the structures.

(2) Deep and thorough anchorage in the bed and banks of the stream.

(3) A fall of not more than 3 feet at each dam to minimize leakage under the dam and scouring by the overfall.

(4) Adequate aprons to conduct discharged water away from the dam without scouring.

(5) Strength and stability to resist static pressure and impact from moving water and ice.

29. Ditch Banks

a. SODDING. Protect overflow channels by dense sod, except where the channel is submerged for long periods or where the water velocity on spillways is too fast.

b. PAVING. Protect channels by paving with stone or concrete masonry as wide and high as necessary to prevent overflow by flood waters. However, the cost of this method is seldom justified.

30. Stream and River Banks

a. CAUSES OF DAMAGE. Damage to stream and river banks may be caused by the following:

(1) Abrupt changes in direction of flow.

(2) Erosive velocity of water.

(3) Wave action.

(4) Drifting ice.

b. CONTROL METHODS. Effective control methods are based on careful investigation and designed for specific conditions. Banks exposed to wave action must be protected well below normal water level.

(1) *Channel realignment.* Damage caused principally by abrupt changes in direction of flow should be permanently corrected by easing the channel alignment and backfilling the old channel if the cost is not prohibitive.

(2) *Vegetation.* (*a*) For restricted channels with steep banks where erosive velocities develop only during high water, decreasing the slope and revegetating may solve the problem (pars. 18 and 19). Stable earth slopes supporting vegetation should not be steeper than 2½:1 to 4:1, depending on the soil type.

(*b*) On banks subject to erosion, an abundant natural growth often insures stability. Willow cuttings are commonly planted for this purpose.

(3) *Mechanical stabilization.* If the erosion is severe and does not respond to natural treatment, the following mechanical means of stabilization are used:

(*a*) Brush mats, securely anchored or staked down.

(*b*) Loosely deposited boulders.

(*c*) A series of triangular breaks of piling and timber cribbing with rock and brush backfill, to deflect the water from stream banks and to reduce edge velocities.

(*d*) Timber, brush, rock jetties, and baffles.

(*e*) Cribbing walls, securely anchored and protected from wash.

(*f*) Retaining walls with substantial footings and weep holes or other means of draining the embankment.

(*g*) Slope paving of riprap or bags filled with a lean mixture of 1 part portland cement to 10 parts sand or pit-run gravel.

(*h*) Slope paving with the mortar-rubble masonry or concrete if the high cost of such work is justified.

31. Levees

Levee slopes require the same protection and maintenance as other stream banks, except for the special care necessary to prevent erosion, destruction of ground cover, and damage from burrowing animals. If the top of the levee is a road, keep ruts and depressions well filled. When overflow becomes imminent, control water by sand bags on top of the levee.

a. Grass Cover. The slopes of levees can best be stabilized and protected by tough, spreading type grass cover. Such grasses as brome, western wheat, Bermuda, Kikuyu, and Kentucky bluegrass are all excellent. Flood waters deposit many weed seeds and weaken the grass temporarily. Mow weeds to prevent their shading and crowding out the grass. Once or twice during the summer is usually enough after the grass is established.

b. Floodgates. Inspect automatic floodgates periodically and remove any obstructions. Close manual floodgates before water rises to flood stage, and open them to permit normal surface water drainage when the flood subsides. Inspect and repair or replace cut-off walls at floodgates to prevent leakage or undermining during high water.

Section VI

TREES, SHRUBS, AND VINES

32. Selection

a. GENERAL. Select trees and shrubs from a nearby locality because plants brought from a distance may not survive if they have grown under different climatic conditions. At seacoast locations, select plants growing in the immediate vicinity because the usual flowering garden shrubs cannot survive severe winds and salt spray. Require that the roots of bare-root trees and shrubs be puddled before delivery in a soil-and-water solution dense enough to stick to all parts of the root system. Specify that all plants be protected from drying out in transit.

b. TYPES. (1) *Trees.* Select trees adapted to the site. Use nursery-grown hardwood trees for street plantings. Do not plant low-branched, bushy trees, or softwood trees along streets because low branches interfere with traffic and the softwood roots damage pavements and sewer lines. Softwood trees are usually short-lived and require excessive maintenance. Trees collected in woods are not usually suitable for street planting because of the difficulty in taking enough root for transplanting; they seldom have tops as well developed as nursery-grown trees.

(*a*) Select a species that gives at least 25 years of service. Consider the ultimate growth of the trees and the amount of shade given at maturity.

(*b*) Choose trees with straight trunks. Require that the leader development of single-leader trees be normal for the variety and that open-head trees have U-crotches. Reject trees with V-crotches because they split before reaching maturity.

(*c*) Reject trees with bark abrasions and diseased or insect-infested trees.

(2) *Shrubs.* Select a moderate variety of nursery-grown shrubs. Planting a few shrubs of great variety presents a confused appearance. Select evergreen species having a compact growth habit and good color of foliage.

(3) *Vines.* Select vines to suit the results desired. Some vines grow slowly and produce a fine pattern while others grow rapidly and form a screen. Quick-growing deciduous type vines such as 2- to 3-year field-grown plants are satisfactory. Good slower-growing vines are the evergreen or semievergreen types such as 2- to 3-inch pot-grown plants delivered in paper pots.

c. SIZES. (1) *Trees.* The caliper size of trees is the diameter of the trunk taken 1 foot from the ground.

(*a*) For ease in handling and economy, select most shade trees with caliper size of 2½ to 3 inches.

(*b*) For street plantings, use 2½- to 3-inch caliper with branches 6 to 7 feet from the ground. This size is usually 14 to 16 feet high depending on variety and can be transplanted bare root, especially in the spring. Move any trees over 4 inches in caliper size with a ball of earth and platform to insure successful transplanting.

(*c*) To keep plantings near large buildings in scale, select trees of 4- to 5-inch caliper. Although trees much larger than this can be transplanted by trained personnel, costs of tree moving rise sharply as caliper size increases.

(*d*) When mixed with shrubs, different-sized trees give a natural appearance. Vary them from 1-inch to 5-inch caliper with most of them within the 2- to 3-inch group.

(2) *Shrubs.* Select vigorous, multiple-stemmed, deciduous shrubs 1½ to 5 feet high for landscaping around one-story buildings. The increased expense and greater hazard in transplanting large shrubs is justified when height or immediate full growth is essential.

33. Planting Locations

a. TREES. Plant one variety of tree along one street. When replacing street trees where several varieties were used initially, replace with the predominant existing variety. Do not plant trees between the curb and the sidewalk. Space street trees from 35 to 50 feet apart, depending on the growth habit of the species selected.

b. SHRUBS. (1) Use shrubs in massed groupings to define recreation areas and at building foundations to eliminate the right-angle line of foundation and earth. Do not scatter shrubs as single plants over lawn areas or plant them in straight unnatural rows. Scattering the shrubs greatly increases lawn-mowing time.

(2) Use tree-like shrubs with shade type trees in a massed shrub planting to further simulate natural grouping.

(3) Do not plant groups of shrubs around raised utility manholes or similar objects to hide them. The shrubs only invite attention to the object.

c. VINES. Vines are used to create an interesting pattern, or a softening effect, on walls and buildings; they are grown on fences for screening purposes. The erosion-control value of most vines is limited. Vines are usually planted 2 or more feet apart, and unless cereal grains are sown with the vines, erosion takes place between the plants before they blanket the slope.

34. Time of Planting

Plant deciduous trees and shrubs in spring before growth starts, or in the fall after the leaves turn color or drop. Plant narrow-leafed evergreens in early spring before new growth is made or in the early fall after new growth hardens. Plant broad-leafed evergreens in the late spring. Because climatic conditions vary, specific planting dates cannot be given.

35. Planting Methods

a. TREES AND SHRUBS. (1) *Care before planting.* (*a*) Dig the tree pits before the trees arrive so trees are out of the ground no longer than necessary. Large-sized balled and burlapped trees should be placed in the holes directly from the truck.

(*b*) If leaving the plants out of the ground for a few days becomes necessary, cover the balls of earth with soil to prevent the roots near the surface from drying out.

(*c*) Cover the roots of all bare-root trees and shrubs with wet burlap or similar material as soon as they are unloaded if planting is to take place within a few hours.

(*d*) Heel in all other bare-root trees and shrubs at once in a trench deep enough and wide enough for the roots of the plants (fig. 47). Place them at a 45-degree angle, and cover the roots with soil to prevent drying. When shrubs are delivered in bundles, keep the bundles intact to facilitate future handling. Avoid injury to plants by rough handling. When removing plants from the heeling-in trench, uncover roots carefully. Do not grasp the tops of the plants and pull them out of the trench without removing the soil. Locate the heeling-in ground as near the final planting site as possible, preferably where water is available.

Figure 47. Heeled-in shrubs.

Water heeled-in stock periodically if the plants are to stay in trench longer. Do not wash the soil away from the roots when watering.

(2) *Planting pits.* (*a*) In digging planting pits for trees, separate the soil into three piles: sod, topsoil, and subsoil. Use the salvaged sod elsewhere to repair grassed areas. Arrange the piles to keep open the side of the pit from which the tree will be placed.

(*b*) Dig planting pits wide enough to accommodate all the roots without crowding or twisting. Dig treepits at least 1 foot wider than the spread of roots or ball of earth. Prepare all planting pits with straight sides. Dig tree pits just deep enough to permit the top of the ball to be flush with the existing grade. Deeper planting prevents enough air from reaching the roots and may kill the tree.

(*c*) Shape the pit bottom with the center slightly raised for proper drainage. Place about 6 inches of compacted topsoil in the bottom of the pit.

(3) *Setting plants.* (*a*) If the tree is delivered on a platform, tip the ball on its side by pushing against the ball after it is set in the hole (figs. 48, 49, and 50). Do not crack or damage the earth ball. Cut the ropes holding the platform and remove platform from the pit. Carefully right the tree by lifting against the ball. Cut the rope lacing and cut away as much burlap wrapping as possible. Leave the burlap in place under the ball because it soon disintegrates in contact with

soil. To prevent crumbling, do not cut rope lacing while the tree is tipped. Remove the burlap from all balled shrubs that can be lifted easily.

(*b*) Set all plants plumb before backfilling. Avoid straightening trees or shrubs after the backfill has been placed. Damage to plants may result from air pockets formed under the roots when the tree or shrub is moved.

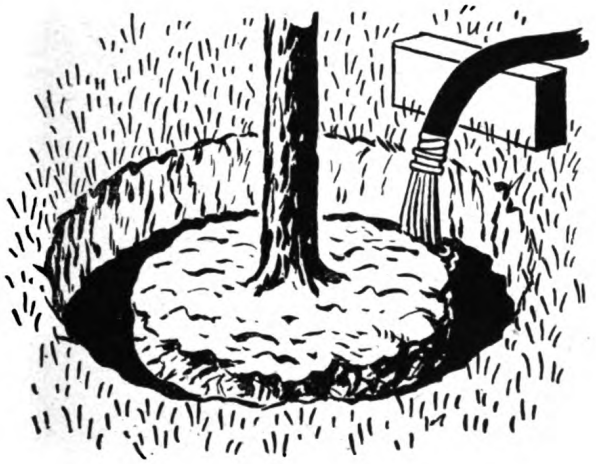

Figure 48. Set plants plumb before backfilling.

Figure 49. Backfilling.

(4) *Backfilling.* (*a*) *Balled and burlapped trees* (figs. 48, 49, and 50). Backfill the space between the ball and side of planting pit with good loam topsoil. Work soil under the ball to eliminate air pockets. Place backfill in 6-inch layers, using the salvaged topsoil. Firm each layer by trampling until the planting pit is half filled. If the soil is wet, use a light wood tamper instead of trampling because heavy compaction of wet soil reduces the air space too much. If the soil is reasonably dry, fill the remainder of the pit with water to settle the backfilled soil. Allow the water to be absorbed

Figure 50. If soil is dry, fill pit with water to settle backfill.

and fill the planting pit, tamping the upper soil lightly after the water is added to prevent tight compaction.

(*b*) *Bare-root plants.* After placing the backfill under a bare-root tree or shrub, add enough topsoil to cover the roots. Add water until the soil becomes a thick liquid. Gently raise and lower the tree to allow the soil to fill between the fibrous roots. Continue adding soil and water until the planting pit is filled to grade.

(*c*) *Settlement.* After the water has drained away, check all planting pits for settlement and add enough soil to bring them up to grade, keeping the surface sloped slightly toward the tree.

(5) *Earth ring.* If planting is done in the spring, make an earth ring about 3 inches high around the planting pit to hold water. Omit earth rings around trees and shrubs planted in the late fall, and level all existing rings in the fall because water collects inside the rings which may freeze the plants.

(6) *Dry planting.* If water is not available at planting time, carefully work the loose soil around the roots by raising and lowering the tree slightly. Cover the roots with soil, backfill, and tamp the topsoil in 6-inch layers. (See figs. 51 through 56.)

b. VINES. (1) *Field-grown vines.* Plant field-grown vines by digging individual soil pockets wide enough for the roots without crowding. Place about 2 inches of topsoil under the plant. Firm the soil around the roots with the hands until the planting pocket is filled.

(2) *Pot-grown vines.* Remove pot-grown vines from the containers carefully to avoid breaking

Figure 51. Dig a large hole in well-prepared soil.

Figure 53. Work finely pulverized soil in and around roots.

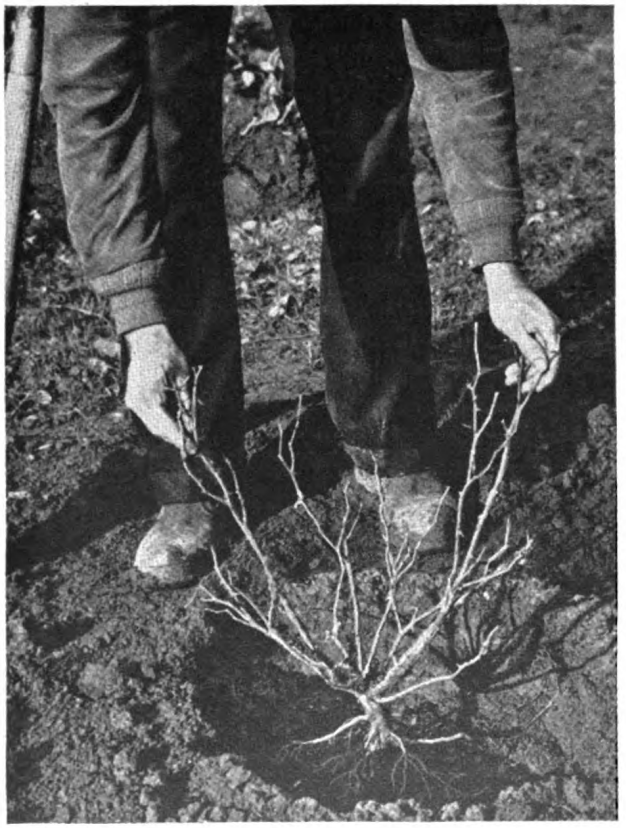

Figure 52. Hole must accommodate roots without crowding. Spread roots nearly horizontal.

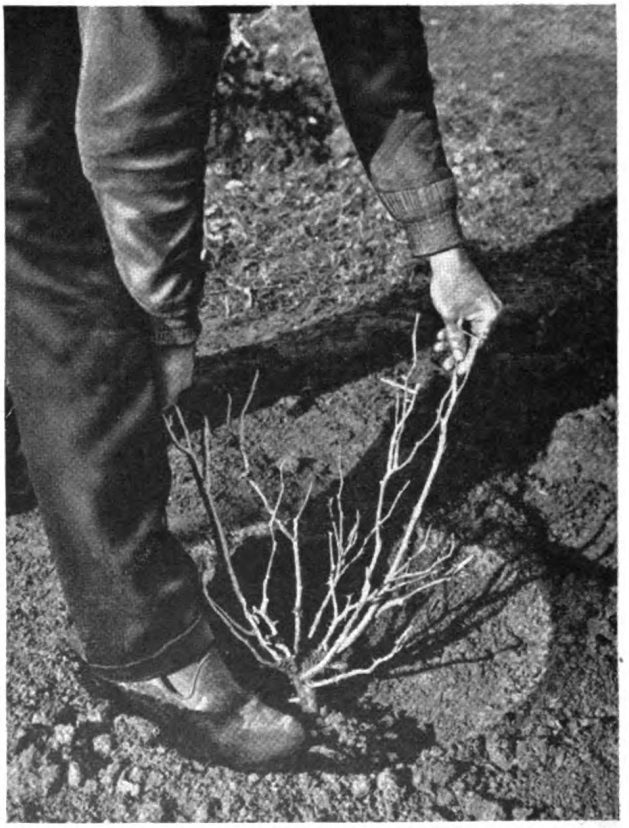

Figure 54. Firm soil by stepping full weight around bush.

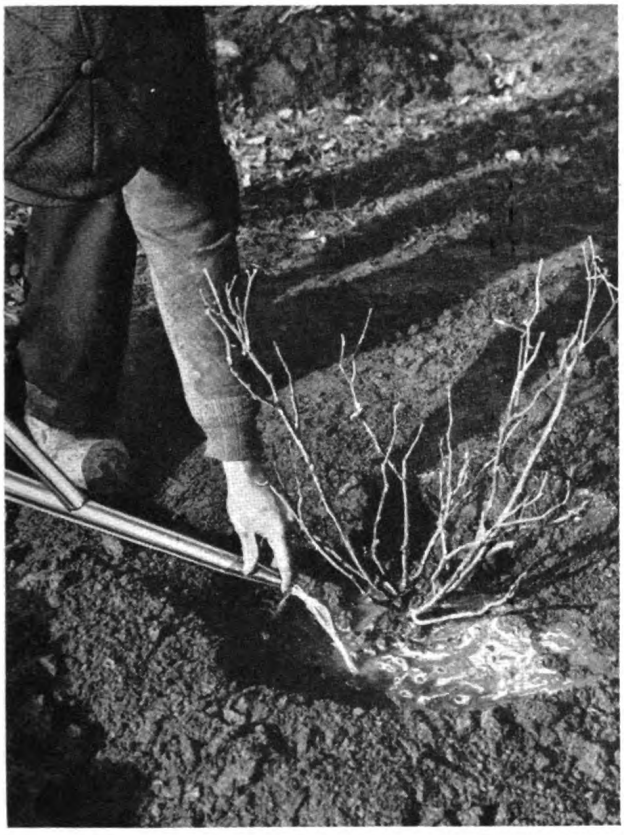

Figure 55. Water thoroughly with gentle flow, filling hole several times if necessary.

Figure 56. Cover so knobby, swollen area of stem is about 1 inch below soil level.

the soil around the roots. Set 2- to 3-inch pot-grown vines in planting pockets about 6 inches wide and proceed as in planting field-grown vines.

36. Staking and Guying

Stake or guy all trees and treelike shrubs immediately after planting. Unless they are guyed at once, newly planted balled and burlaped trees are loosened from the ball by the wind; both bare-root and balled and burlaped trees may be pushed out of alignment and need to be pulled back to a vertical position. If a tree is straightened after planting, not only may air pockets be formed around the roots but all the strain is placed on one stake or guy wire. Keep tension on all stakes or guy wires equal. Do not guy where foot traffic passes.

a. STAKING. (1) *Street trees.* (*a*) Stake street trees up to 3-inch caliper with two stakes on opposite sides of the tree about 18 inches from the trunk and parallel to the curb. Use cedar stakes with the bark attached if available. Select stakes 8 feet long with a diameter of about 2 inches at the top and about 3 inches at the butt. Drive stakes 3 feet deep at a slight angle away from the tree.

(*b*) Stake street trees of 4- to 5-inch caliper with 4 stakes 10 feet long, driven 4 feet into the ground. Place the stakes in box formation at equal distances 18 inches from the tree.

(*c*) Place scrap-rubber hose 1 to 2 inches in diameter around the tree trunk near the top of the stakes to prevent damage to bark by supporting wires. If scrap-rubber hose is not available, use fairly thick cloth wrappings, or laths cut 6 inches long, where the wire makes contact with the tree.

(*d*) Use 12-gauge wire between the stakes and the tree. Cut the wire in proper lengths and draw it through the rubber hose or around the protective collar until the cut ends meet. Pull the ends of the wire around the stake near the top until taut. Wrap the cut ends around the stake and twist them together on the inside of the stake. Secure tree to the second stake in the same way. To give added tension, use a rack stick between the doubled wire.

(2) *Shrubs and small trees.* Stake tree-like shrubs and small evergreen trees with single stakes placed on the side toward the prevailing winds. Set the stake about 1 foot from the trunk and about 2 feet deep. When planting bare-root

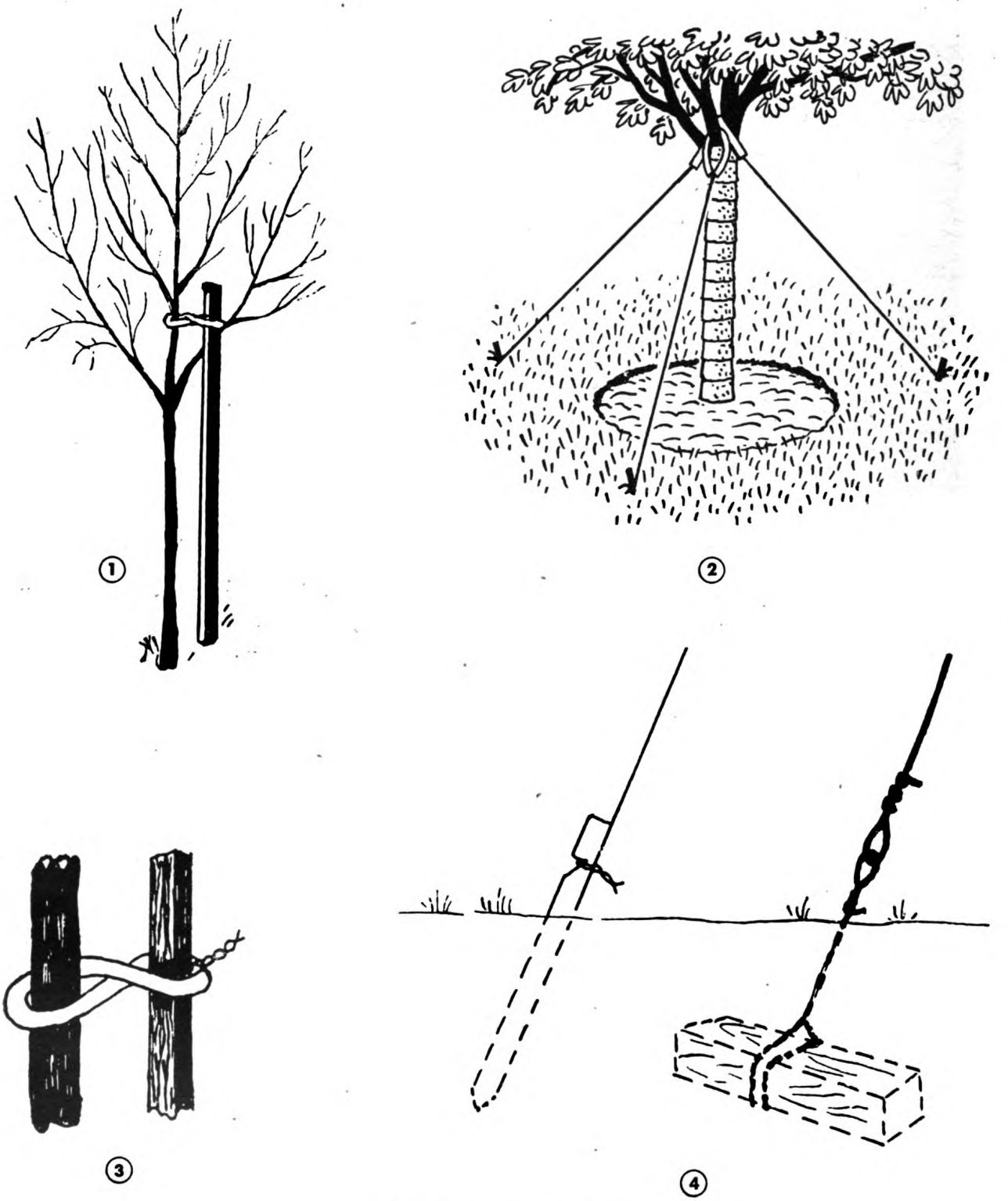

Figure 57. Guying newly planted tree.

stock, drive the stake before setting the plant to prevent injury to the roots. Use scrap-rubber hose and 12-gauge wire as described above. If ½-inch rope is used instead of wire and hose, cross rope between stake and tree, wrap loose ends once around the stake, and tie in place with a square knot.

b. GUYING. (1) Guy trees up to 4-inch caliper in nontraffic areas from three directions.

(*a*) Drive three 4-foot stakes, cedar or scrap lumber, equally spaced around the tree outside the planting pit. Place the stakes so guy wires do not interfere with the lower limbs. Notch stakes near the top on side away from tree. Drive them to within 6 inches of the top at a slight angle away from the tree.

(*b*) Place scrap-rubber hose or protective collar around the trunk about 6 feet from the ground. For street trees, put wrapping slightly above the lower limbs.

(*c*) Run a single strand of wire through or around the protective collar and back to the stake. Cut the wire free from the coil, allowing enough slack to fasten the wires securely and to permit driving the stake below ground level. Repeat for the other two stakes. Get the same tension on all guys to give proper alignment. If the tree settles, tighten the guys by driving the stakes deeper or inserting a rack stick between the double wires.

(2) Guy 5-inch-caliper trees with two double strands of 12-gauge wire attached to three 2- by 4-inch stakes, 4 feet long, in the method shown for 2- to 3-inch caliper trees.

(3) Remove identification tags and labels from trees to prevent wire or cord from constricting the limb or trunk as the tree grows.

(4) Remove guy wires and stakes the second year after planting. The root growth by that time is anchored firmly. Failure to remove the guy wires may cause total or partial girdling as the tree grows against the constricting wire.

37. Wrapping

Wrap trunk and lower parts of the first limbs with burlap or crepe paper 6 inches wide to reduce the amount of water given off by the tree through the bark while the roots are becoming established (fig. 58).

a. Start at the lower part of the bottom branches and wrap spirally to the ground. Overlap half of each spiral to form a double wrapping. Secure the last wrapping with twine, winding the twine in wide spirals up the trunk and tying it above the lower branches.

Figure 58. Method of wrapping newly planted tree.

b. Do not wrap tree species subject to borers because the larvae may work undetected beneath the wrapping.

38. Waxing

Several paraffin-base preparations are used for spraying newly planted trees to reduce the amount of water given off through the bark pores. This spray takes the place of burlap or crepe-paper wrappings.

a. Prepare the material according to the manufacturer's directions and apply as a fine spray. Limit the spray to the heavy limbs and trunk. Do not cover entire tree.

b. Do not use these sprays for trees having thin bark, such as dogwood and sugar maple unless the ingredients are known to be harmless.

39. Watering After Planting

a. NEED. The need for water by newly planted trees, shrubs, and vines depends on temperature, water-holding capacity of the soil, drainage, and normal rainfall.

(1) Generally plants do not need watering in cool weather. In hot, dry periods, artificial watering is necessary the first year after planting.

(2) Too much watering in clay soils may reduce soil temperature and retard plant growth. It also may flood the soil enough to prevent air from reaching plant roots and drown the plant.

(3) To determine need for watering, dip up a shovelful of earth and test the soil below the

first few inches. If it keeps the shape of a ball squeezed in the hand, watering is not necessary.

b. Method. When watering is required, soak the soil thoroughly. About 27,000 gallons of water per acre equals 1 inch of rainfall or a little over ½ gallon per square foot. Clay soils generally require ½ gallon per square foot, while sandy soils require 2 gallons; soils between these two extremes require about 1 gallon.

40. Pruning Trees

Prune trees at the time of planting to insure well-developed framework and to reduce top growth to compensate for roots lost in moving. Do not cut back vigorous trees that are thoroughly thinned out at time of planting. Cutting back the branches removes a year or more of growth and gives trees a formal shape until the condition is outgrown.

a. New Trees. Prune the tree before setting it in the hole to save time and trouble. Hand tools can be used which cut closer than the pole pruners needed for trees in an upright position. Start at the top of the tree and work down; remove closely parallel branches, crossing and broken limbs, and superfluous growth at the base of the main branches.

(1) *Cutting branches.* (*a*) When removing a branch, make the cut flush with the main branch (fig. 59). Do not leave a short stub because the healing callus cannot close over the stub, which decays and may permanently injure the tree. When cutting back a branch, cut to a bud so as not to leave a stub.

(*b*) Paint all pruning wounds over 1 inch in diameter with a tree-wound compound to retard checking and decay of the exposed wood.

(2) *Cutting leaders.* When pruning, do not cut back the central leader. When the terminal bud is removed, the one nearest the cut becomes the terminal bud. On trees with opposite buds, each bud produces a shoot that competes with the other, and a structurally weak double-leader tree results. Cutting back the leader of an oak tree flattens the top and stunts the tree.

b. Existing Trees. (1) *Workmen.* (*a*) When large trees are pruned, require that the climber be experienced and climb with 125 feet of ½-inch rope having a bowline knot in one end. The climber passes the bowline through a stout crotch and places it around his thighs, using the loose end or tail of the bowline to tie a taut-line hitch in the rope leading to the ground. The climber is free

Figure 59. Correct and incorrect method of removing branch stubs.

to work with both hands and can swing back to the trunk without injury if a limb breaks.

(*b*) Always have a ground man work with a climber to tie needed tools to the rope and to keep it free of brush. When pruning street trees, the ground man must keep the climber's rope out of the road to avoid serious accident.

(*c*) Pruning large trees from extension ladders is hazardous. Satisfactory work cannot be done because pole saws and pole pruners must be used instead of hand tools.

(2) *Procedure.* (*a*) Prune large trees by working from the top down. Prune each large branch individually. Remove crossing limbs, broken branches, and superfluous growth next to the tree to admit sunlight and air circulation to aid insect and disease control. Paint all pruning cuts with a tree-wound compound immediately.

(*b*) To remove large, dead, or broken branches, make three saw cuts to prevent ripping the bark of the tree trunk (fig. 60). Start the first cut on the underside of the limb about 1 foot from the trunk and saw through one-third of the branch.

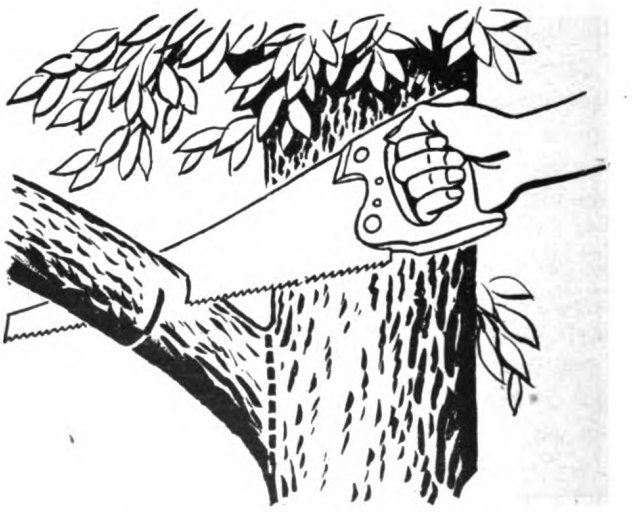

Figure 60. Method of removing large limb. Final cut is made along dotted line to allow tree to heal over wound.

Start the second cut on top of the branch about 3 inches behind the bottom cut, sawing until the branch splits off at the parallel point of the two cuts. Saw off the stub flush with the trunk to allow the wound to heal and paint with tree-wound compound.

41. Bark Tracings

Treat bark abrasions on tree trunks promptly to permit rapid healing of the wound and prevent decay.

a. Tools and Materials. A sharp, curved-blade pruning knife and a ½-inch paint brush are needed. If the bark is thick, a sharp wood chisel and light mallet are used to cut it. A small quantity of shellac and tree-wound paint are necessary materials.

b. Procedure. (1) Determine extent of injury and carefully remove all loose bark.

(2) Start the bark tracing in sound bark above injury and work knife or chisel down on a slight curve to one side of injury, removing all sprung bark (fig. 61). Hold chisel at a slight angle away from injury with beveled edge toward the sound bark.

(3) Shellac exposed edge of bark as tracing progresses to prevent drying.

(4) Continue tracing downward until distances above and below center of injury are equal. Repeat procedure on opposite side of injury.

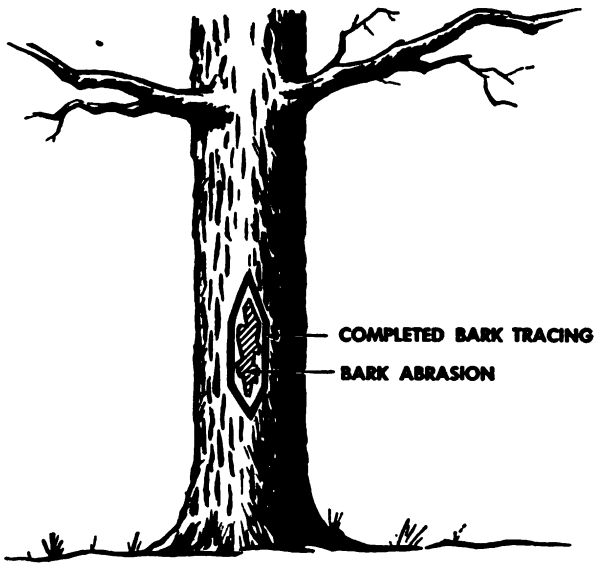

Figure 61. Bark tracing of abrasion on trunk of tree.

Apply a second coat of shellac to exposed bark edge. Paint the exposed wood with a tree-wound compound.

(5) The top and bottom points of the tracing must be established on the center line of the injury to permit uniform healing. The healing callus does not develop on the lower side of a bark tracing made on an angle.

(6) When two small injuries are close together, make one bark tracing because the thin strip of bark between two abrasions dries out and the tracing must be repeated.

42. Pruning Shrubs

a. General. Remove part of the woody growth of deciduous shrubs when transplanting to compensate for partial loss of the root system. Shrubs pruned when planted recover and regain natural shape more quickly then unpruned plants. In general, prune away about one-third of the top growth. Shrubs produce new growth near the the base of the plant while trees grow from the ends of the branches. Tree trunks do not push upward; a nail driven 3 feet above the ground always remains at that height. Established, vigorous shrubs that have not outgrown their location to block sunlight from buildings or interfere with walks do not have to be pruned.

b. New shrubs. Prune all newly planted deciduous shrubs according to their natural habit of growth (fig. 62). Do not shear them uniformly because contrasting growth habits is the reason for planting several varieties. Shearing produces a formal shape, destroys the plant's identity, and is monotonous and unsightly. Cut heavy canes at a greater height from the ground than smaller ones.

c. Established shrubs. (1) Prune old, oversized shrubs by cutting the heavy canes back to the ground so new shoots grow from the base of the plant. Unsightly shrubs can be reclaimed by this method. When a shrub consists entirely of old heavy canes, remove only half of the canes the first year to prevent a mass of stiff stalks with an undesirable brushlike effect (fig. 63).

(2) Prune such shrubs as forsythia immediately after flowering to prevent the following year's bloom from being destroyed. Prune fruiting types before and after they bloom in early spring or in the fall. Shrubs pruned severely in the late fall have a dehorned appearance all winter.

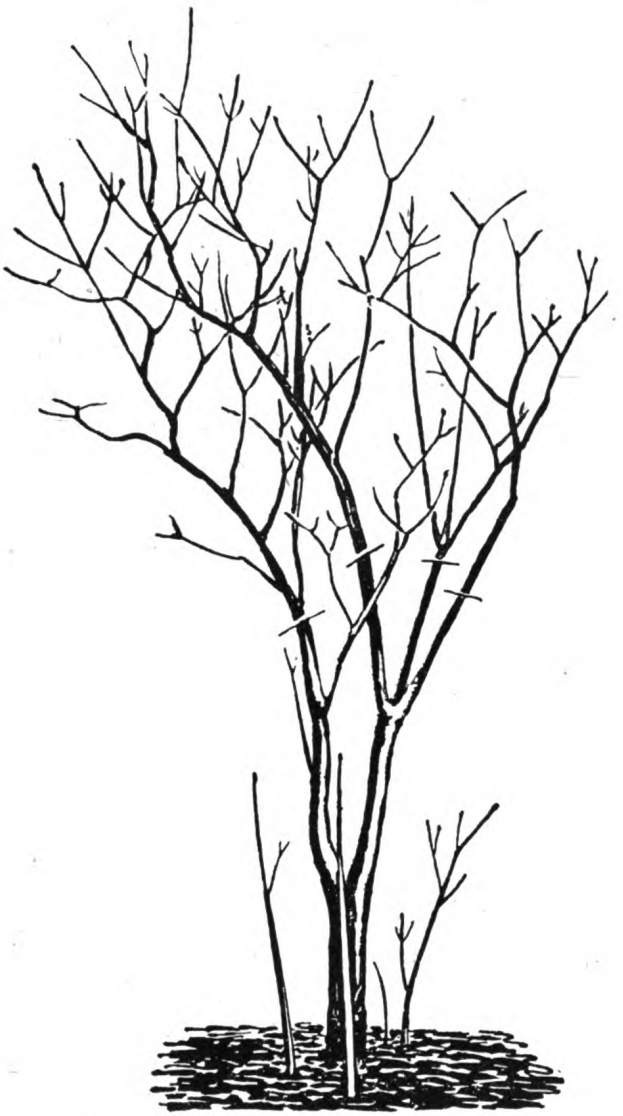

Figure 62. Cut back poorly shaped lilac as indicated by cross lines to renovate it and induce vigorous new growth. No flowers are produced for 1 to 3 years after drastic pruning.

43. Cultivation

Cultivate newly planted trees and shrubs to eliminate weed competition and to loosen the soil for better water and air absorption.

a. TREES. (1) *New trees.* Loosen the earth around newly planted trees for the first year with three or four cultivations to keep the earth loosened and weeds in check. Cultivate about 6 inches deep within the earth saucer.

(2) *Established trees.* Do not cultivate around established trees. Mounding the earth around the trunks of existing trees produces no benefit because most of the feeding roots are located as far from the trunk as the tips of the branches. The roots near the trunk are conducting tubes, not feeding roots. Allow grass to grow up to the trunk to benefit the tree and reduce grounds-maintenance time.

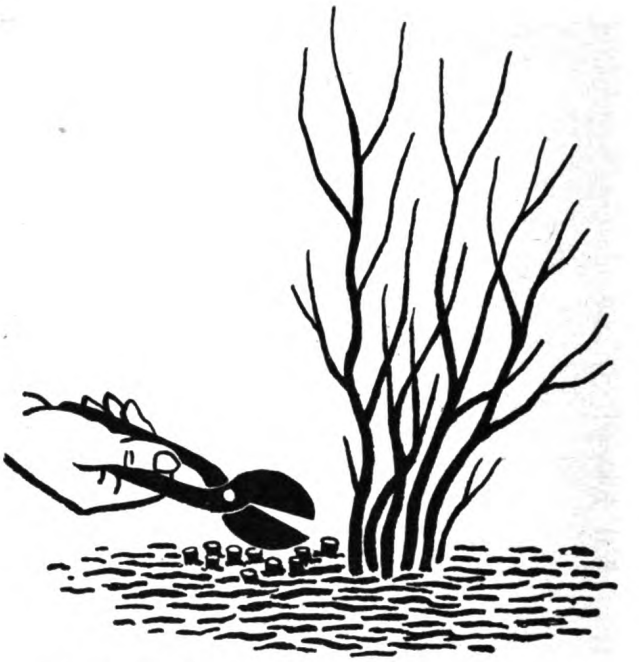

Figure 63. Cut half of old canes back to ground.

b. SHRUBS. (1) *New shrubs.* Cultivate shrub beds once in the spring and once in the late summer for the first 2 or 3 years after planting. Cultivate the area between the shrubs about 6 inches deep and the area at the base of the shrub about 3 inches deep. Dig carefully around the base to prevent damaging the roots.

(2) *Established shrubs.* Cultivation of massed shrub plantings over 3 years old is unnecessary and damages the shrubs. Such shrubs are well rooted and create enough shade to keep weeds in check.

44. Mulching

Apply mulch such as manure and peat to new plantings to conserve moisture and hold weeds in check. Such organic material added at the time of planting lessens or eliminates the need for future mulching.

a. TREES. (1) Mulch trees at time of planting lightly with manure or peat. Do not use manure when trees need an acid soil. Place the mulch within the earth ring.

(2) When trees are planted in the spring dig in the mulch in the fall, raking the earth saucer level. Seed with adapted grasses up to the tree trunk.

(3) When trees are planted in the fall, allow the mulch to remain through the winter. Dig the mulch into the soil in the spring and seed the scarred area.

b. Shrubs. (1) Make light applications of mulch over shrub beds in the fall. Rake off straw litter the next spring and dig the remaining mulch into the soil.

(2) For plants that need an acid soil such as rhododendron, laurel, azalea, and flowering dogwood, use peat of acid composition or oak-leaf compost. Do not use manure when plants need an acid soil.

45. Fertilizing

a. Purpose. Trees, shrubs, and vines need plant food to survive; those growing where leaves and litter are constantly removed by raking may starve unless the food supply is replenished by fertilizer. Plants that are getting enough food have luxuriant foliage of good color; those that do not, have small yellowish leaves and sparse foliage. Undernourished trees and shrubs may die back at the ends of the branches as starvation progresses. Vigorous plants are usually not diseased and recover readily from insect attacks. To overcome plant-food deficiency, use a complete high-analysis fertilizer with the nitrogen derived from an organic source.

b. Limitation. In general, limit use of fertilizer to trees, shrubs, and vines that are not vigorous. Periodic applications of fertilizers are not recommended.

c. Time of Application. Apply fertilizer in the spring when growth is starting to insure full use of the food by the plant. Do not use fertilizers containing chemical nitrogen such as nitrate of soda in the fall of the year. Chemical nitrogen is quickly absorbed by the plant and the new growth is not hardened off before winter killing.

d. Trees. (1) *Amount.* In determining the amount of fertilizer for trees, allow 3 pounds per inch of trunk diameter. For trees over 6 inches in diameter, take the measurement at breast height. Measure trees under 6 inches in diameter 1 foot above the ground.

(2) *Punch-hole application.* (*a*) The punch-hole method of fertilizing employs a crowbar to punch holes 18 inches deep and 2 to 3 feet apart in a double ring around the tree (fig. 64). Use 3-foot spacing for trees 12 inches in diameter or over. Make the first ring of holes under the outer drip of the branches. Put the second ring 2 to 3 feet inside the outer one, depending on the size of the tree. Stagger inner-ring holes between the outer ones.

(*b*) When feeding trees growing in grassed areas, fill the crowbar holes with fertilizer to within 2 inches of the top, and fill the top 2 inches of the holes with soil to prevent the concentrated fertilizer from burning the grass. Where desirable, cut sod plugs before making holes, place a little soil over the fertilizer, replace the sod plug, and tamp it into place.

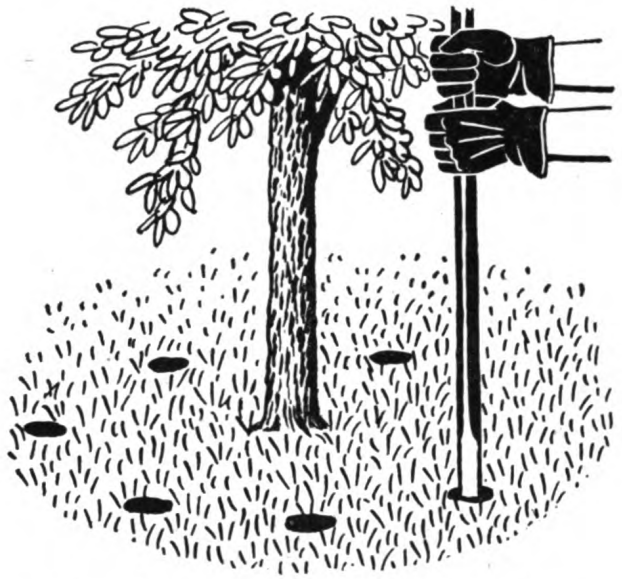

Figure 64. Punch-hole method of feeding trees.

e. Large Shrubs. Apply 1 to 3 pounds of fertilizer to large shrubs, depending on the size and condition of the shrubs. Dig the fertilizer into the soil under the outer branches of the shrub to a depth of 6 inches. Apply the fertilizer to exceptionally large shrubs by the punch-hole system described above.

f. Small Shrubs and Vines. For vines and small shrubs in poor condition, use one or two handfuls of complete fertilizer, depending on the size and plant condition. Work the fertilizer carefully into the soil. Do not let it come into direct contact with the plant roots.

46. Preserving Existing Stands

a. Roads Through Tree Stands. When constructing roads through dense stands of evergreen or deciduous trees, prevent needless damage to existing stands. Remove only those trees in the way of construction, avoiding wide swaths through dense stands because the trees left at the edge of the clearing cannot withstand the increased sunlight and air circulation. Trees suddenly exposed in this way scald and die, causing an unsightly loss of valuable timber.

b. Raising Grade. Construct a dry well around trees when raising the grade is necessary. Increas-

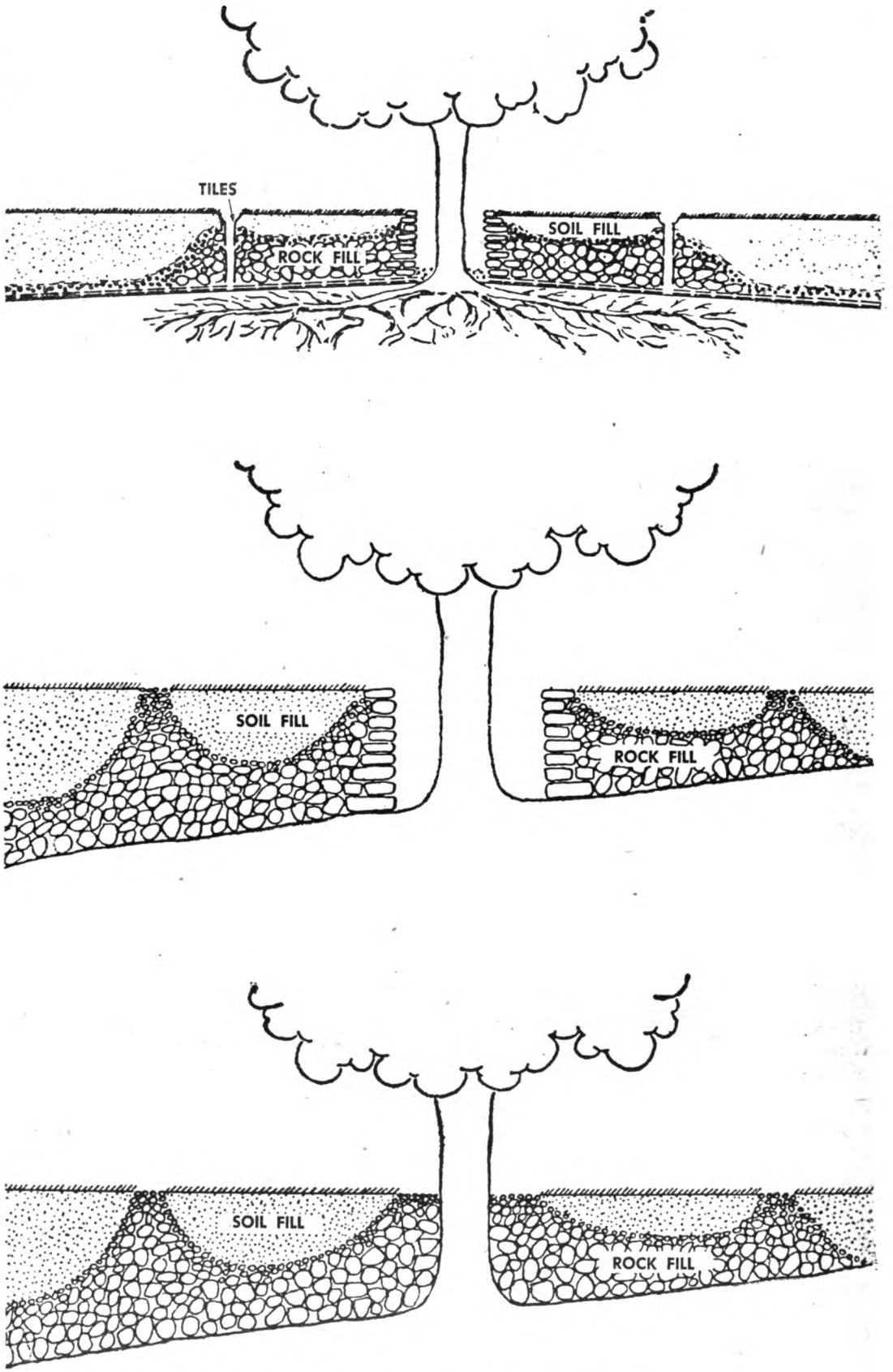

Figure 65. Three types of wells around trees where grade has been raised.

ing the depth of soil over tree roots prevents enough air from reaching the roots and may smother the tree (fig. 65).

(1) Construct the dry well of flat field stone or common brick with open joints placed 1 to 3 feet from the trunk of the tree.

(2) If the fill is to be over 1 foot deep, place a layer of crushed stone from the outer drip of the branches to the dry well, increasing thickness of crushed stone nearer the well. Bring the crushed stone up to level of finished grade to form a ring around the tree under the outer drip of the branches as shown in figure 65. The width of the ring varies from 6 inches to 1 foot, depending on tree size.

(3) Place vertical tile at intervals around the tree in the crushed-stone ring to admit air to the root system.

c. TRAFFIC. (1) Where cantonment areas have been constructed, enforce traffic control to prevent the driving and parking of vehicles among the trees. Vehicles eventually compact the soil so much that air cannot enter the soil and the trees smother.

(2) Where parking and traffic have caused dying back at the ends of the branches, aerate the soil. Commercial tree companies use a machine to force a liquid fertilizer through the ground by compressed air, which loosens the soil around the tree roots and stimulates new growth. Follow liquid feeding by a complete fertilizer with the nitrogen derived from an organic source.

47. Plant Insect and Disease Control

Unless control measures are definitely known, refer problems of plant pest and disease control to the service command engineer and request the technical assistance of the entomologist on duty with that office. (See TM 5–632.)

SECTION VII
POST CEMETERIES

48. Responsibility

Maintenance of post cemeteries is a responsibility of post engineers and includes maintenance of grounds; care of shrubs, trees, and flowers; and the opening and closing of graves.

49. Selection and Planning of Sites

a. LAY-OUT PLAN OF POST. Proposals for post cemeteries, submitted to OCE in accordance with AR 210–500, are accompanied by a small-scale key map or use map of the entire post showing the limits of areas already developed and their present use (housing, storage, warehouse area, training aids, motor storage area, and so on). The use map indicates probable and possible future expansions of use areas and their relationship to proposed cemetery sites.

b. SITES. Criteria for the selection and planning of post cemetery sites at permanent posts are briefly as follows:

(1) *Topography.* Select relatively level ground with gentle pitch for drainage. Turf does not drain freely on a pitch of less than 2 percent except on unusually porous soils.

(2) *Soil conditions.* Choose dry, well-drained soil with water table at least 7 feet below existing surface. Avoid sites showing rock outcrop. Soil data or samples are required by AR 210–500; test pits should indicate depth of water table and existence of rock within 7 feet of surface.

(3) *Surroundings.* Use an isolated site, free from noise and distraction of post activities.

(4) *Approach and accessibility.* Provide easy accessibility. Maintenance economy prohibits more than a single approach.

(5) *Acreage.* Base acreage on estimated burial requirements. Do not plan a post cemetery for more than 25 years of use. See *c* below on planning.

(6) *Foliage.* Although a site with openly spaced trees throughout is desirable, do not choose a site where dense concentration of root growth can disturb graves.

c. PLANNING. Simplicity in lay-out and low maintenance cost are most desirable criteria. Topography dictates lay-out of blocks and roads.

(1) *Lots.* Lots are 10 feet by 5 feet for enlisted men and civilians and 12 by 12 for officers. The maximum size of a block of lots is determined by the requirement that no lot shall be farther than 200 feet from a turf path or road providing hearse access.

(2) *Roads.* Roads, if any, are 20 feet in width. They are designed to fit closely the existing surface, avoiding banks subject to erosion and providing minimum grading but suitable drainage with as few drainage structures as possible. Curves are only desirable because of existing topography or to avoid gradients in excess of 4 percent.

(3) *Paths.* Turf paths used for maintenance are 10 feet wide plus 5 feet of clearance on either side to nearest graves or blocks of graves; paths used only for walks between blocks of graves require 5 feet of width.

d. PLANTING. Lawn type vegetation is most desirable where its establishment is practicable (par. 14). For maintenance of trees and shrubs, see section VI.

50. Private Cemeteries on Military Reservations

a. GOVERNMENT-OWNED PROPERTIES. War Department policy is to acquire title to all cemeteries within the boundaries of military reservations owned in fee by the United States. Commanding officers are responsible for protecting the cemetery by fencing, policing, and patrolling. No legal authority is given for expenditure of funds to improve them. The post commander is responsible for insuring that the cemetery is kept clean and attractive (par. 17*c*, AR 210–10). This responsibility is carried out by the post engineer (par. 2*b*, AR 100–80) and includes any maintenance for cemetery upkeep including grounds, lawns, trees, shrubs, plants, roads, walks, drains, fences, and walls. Burning of weeds and grass cannot be done because it defaces tombstones.

b. LEASED PROPERTIES. On leased properties, the commanding officer is guided by the agreement with the interested parties. He provides for protection of the cemetery by fencing, policing, and patrolling when necessary.

APPENDIX I
REFERENCES

1. Lawns

a. General. (1) Planting and Care of Lawns, U. S. Department of Agriculture, Farmers' Bulletin No. 1677.

(2) Manual of the Grasses of the United States, U. S. Department of Agriculture, Miscellaneous Publication No. 200.

(3) Lawns, U. S. Department of Interior, P. T. Series No. 14.

(4) Lawn Care, O. M. Scott and Sons Company, Marysville, Ohio.

b. New England and Northeastern States. (1) Turf Management, Connecticut Agricultural Experiment Station, Circular No. 139, New Haven, Connecticut.

(2) Lawn Management, Massachusetts State College Extension Leaflet, No. 85, Amherst, Massachusetts.

(3) New Lawns, Cornell Extension Bulletin, No. 429, Ithaca, New York.

(4) Lawn Management, Cornell Extension Bulletin, No. 430, Ithaca, New York.

(5) Lawn Grasses and Their Management, Rhode Island Agricultural Experiment Station Bulletin, No. 264, Kingston, Rhode Island.

(6) Liming Lawn Soils, New Jersey Agricultural Experiment Station Circular, No. 362, New Brunswick, New Jersey.

c. Middle West and North Central States. (1) Lawn Building Maintenance and Renovation, Iowa State College Extension Circular, No. 242, Ames, Iowa.

(2) Date and Rate of Lawn Feeding, Minnesota Agricultural Experiment Station Bulletin, No. 355, St. Paul, Minnesota.

(3) Making the Home Lawn, Minnesota Agricultural Extension Special Bulletin, No. 130, St. Paul, Minnesota.

(4) The Lawn, its Making and Maintenance, Purdue Agricultural Extension Bulletin, No. 254, La Fayette, Indiana.

(5) Development and Care of Lawns, Missouri Agricultural Experiment Station Circular, No. 204, Columbia, Missouri.

(6) Lawns, Ohio Agricultural Extension Bulletin, No. 129, Columbus, Ohio.

(7) Lawn Experiments, Ohio Agricultural Experiment Station Bulletin, No. 613, Wooster, Ohio.

(8) Growing Beautiful Lawns, Michigan Agricultural Experiment Station, East Lansing, Michigan.

d. Southern States. (1) The Lawn, Kentucky Agricultural Extension Circular, No. 256, Lexington, Kentucky.

(2) The Lawn, Alabama Agricultural Extension Circular, No. 173, Auburn, Alabama.

(3) Lawns for Georgia, Georgia Agricultural Extension Bulletin, No. 324, Athens, Georgia.

(4) Lawns in Florida, Florida Agricultural Experiment Station Bulletin, No. 209, Gainesville, Florida.

e. Great Plains and Western States. (1) Planting and Maintaining Colorado Lawns, Colorado Agricultural Experiment Station Bulletin, No. 442, Fort Collins, Colorado.

(2) Buffalo Grass for Lawns, Nebraska Agricultural Experiment Station Bulletin, No. 63, Lincoln, Nebraska.

(3) Lawn Weeds and Their Control, Utah Agricultural Experiment Station Circular, No. 117, Logan, Utah.

(4) Turf Diseases and Their Control, Oregon Agricultural Experiment Station Circular No. 170, Corvallis, Oregon.

2. Roadside-erosion Control

a. Roadside Development, Part II. Report of April 1940, Highway Research Board, Division of Engineering and Industrial Research, National Research Council, Washington, D. C.

b. Roadside Development. Report of May 1941, Highway Research Board.

c. First Short Course in Highway Development, Ohio State University, Columbus, Ohio, 1 March 1941 (mimeographed). Ohio State University or Ohio State Highway Department, Columbus, Ohio.

d. Report of Subcommittee on Plant Ecology, The Selection and Use of Ground Covers on Highway Areas. Highway Research Board, December, 1939.

e. Military Roads in Forward Areas. Manual of Engineering Practice No. 23, 1941. American Society Civil Engineers, 33 West 39th Street, New York City.

f. Truck Trail Handbook. Chapter V, Erosion Control and Roadside Treatment. Forest Service, U. S. Department of Agriculture (undated, mimeographed).

g. Soil Erosion and Dust Control, Chapter XXIV, Engineering Manual, OCE.

3. Trees and Shrubs

a. Transplanting of Trees and Shrubs in the Northeastern and North Central United States. Prepared for U. S. Army, Camouflage Branch, Engineer Board, by the National Shade Tree Conference and National Arborist Association, September 1943.

b. Engineering Manual, January 1943, chapter XXII, part VI, Establishment of Woody Plants, and Part VII, Maintenance of Woody Plants.

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